AN ECOLOGICAL ASSESSMENT OF STREAMS IN GAITHERSBURG, MARYLAND: 2001-2002

Prepared for

City of Gaithersburg
Office of the City Manager
31 South Summit Avenue
Gaithersburg, Maryland 20877

Prepared by

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9200 Rumsey Road
Columbia, Maryland 21045

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Versar INC.

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1.0 INTRODUCTION

The City of Gaithersburg in Montgomery County, Maryland, is a highly urbanized area in the Washington, D.C., metropolitan area that continues to experience rapid growth and development. Given the potential for urban watershed stresses to impact the environmental quality of the City's freshwater streams, the City sponsored a study during 2001-2002 to evaluate stream conditions and identify restoration opportunities. The objective of the study was to provide an ecological assessment of water quality and resource conditions within the City's more than 24 miles of streams and to identify restoration opportunities that could improve conditions within and along these streams. This report documents the findings of this study conducted by Versar, Inc., under contract to the City of Gaithersburg (Water Quality Analysis and Stream Assessment Services, Resolution No. R-87-01).

1.1 BACKGROUND AND STUDY OVERVIEW

A previous assessment of these streams was completed in 1996 (EQR 1996) using the Modified Rapid Stream Assessment Technique (MRSAT). This 1996 study, however, did not collect sufficient data to form a complete baseline for water resource management in the face of past and future growth. For the present study, the City selected stream monitoring methods used by the Maryland Biological Stream Survey (MBSS) and Montgomery County. The MBSS is a program of the Maryland Department of Natural Resources to characterize and assess biological, chemical, and physical condition of streams throughout the state. Montgomery County Department of Environmental Protection (DEP) has operated its own stream monitoring program since the early 1990s to provide information for watershed management efforts. Montgomery County has itself incorporated a great many of the MBSS methods into its local monitoring program. By adopting the methods of these successful programs, results from the City of Gaithersburg's assessment may be integrated and compared with those from the surrounding County and other parts of Maryland.

A three-part study was initiated to assist the City in characterizing the streams within the City boundaries. The first part of the study was a stream monitoring program using MBSS and Montgomery County protocols. This program was designed to provide the City with a clear picture of current stream conditions and to facilitate the identification of current and future problems. MBSS and Montgomery County protocols provide a standard method for use in the mid-Atlantic region and allow for comparison of results with conditions expected for healthy streams in the region–a critical step in evaluating biological effects. Applying standard protocols allows for quantitative assessment of results using benthic and fish Indices of Biotic Integrity (IBIs), developed and validated by Maryland DNR and Montgomery County; these IBIs represent the most robust biological indicators available for streams in the mid-Atlantic Piedmont region. Biological assessment is accomplished by monitoring both benthic macroinvertebrates inhabiting the streambed and freshwater fish species composition and relative abundance. Physical evaluations included in these protocols involve both geomorphic and physical habitat characterization. Because the data collected as part of this study were collected in a manner consistent with both Montgomery County and State monitoring programs, results could also be used to enhance assessments by these agencies.

The second part of this study involved the identification of areas for stream restoration. Given the extensive urban development within Gaithersburg, much of which occurred prior to current stormwater regulations, streams have been substantially degraded. As the City had already begun to correct many of the problems already identified–including physical habitat impacts such as sediment deposition, point bar formation, and channel instability–the City's environmental managers were seeking additional information on the best locations to target their restoration efforts. This task focused on identifying those sites within the City where restoration would be most cost-effective and would provide the greatest ecological benefit. A restoration targeting approach based on both new and existing data was used to (1) determine the general problem types and trends in stream condition; (2) develop criteria using existing information to distinguish problem types; (3) identify areas or sites experiencing degradation and the most likely causes of these problems; (4) develop and apply criteria to rank candidate restoration sites; and (5) recommend site-specific restoration measures.

The final component of this study was the identification of potential citizen monitoring locations within the City of Gaithersburg. City managers are interested in initiating a program of citizen volunteer monitors to gather data on stream condition. Well-trained volunteers can provide data useful for environmental management. In addition, the educational experience gained by citizen volunteers can raise public awareness and involvement. Stream sites that were visited during the course of both the stream assessment and the identification of restoration sites were evaluated as potential citizen monitoring sites. A list of candidate sites was compiled and a map of the sites was prepared for this report.

1.2 ROADMAP TO THIS REPORT

This report presents the methods and findings for each component of the three-part City of Gaithersburg stream assessment. It integrates the results from each component and presents recommendations to the City for future monitoring and restoration efforts.

Section 2 of this report describes the methods and results of the stream assessment. Protocols for selecting sample locations, collecting field and laboratory data, and analyzing data are described. This section documents the findings of the physical, chemical, and biological stream monitoring. Section 3 details the identification of restoration sites, including the methods used to select candidate sites and the ranking system developed to select the best restoration opportunities. The most promising restoration sites are presented in detail, along with site-specific recommendations on what restoration techniques are most appropriate. The list of potential citizen monitoring sites is included in Section 4. An integrated summary and a list of recommendations are found in Section 5. References are located in Section 6. Examples of field data sheets, stream cross-sections, and a complete benthic taxa list are located in the appendices.

2.0 STREAM ASSESSMENT

This stream assessment was developed for the City of Gaithersburg to characterize stream health and water quality under present conditions and to establish a baseline for evaluating future conditions as new developments are built. Specific elements of this investigation included accurate and intensive assessments of instream physical habitat, biology, and water chemistry. In addition, land use data were used to characterize watershed conditions.

2.1 METHODS

Sampling protocols were based on those developed by the MBSS (Kazyak 2001) and Montgomery County DEP (Van Ness et al. 1997). Examples of field data sheets are found in Appendix A.

2.1.1 Site Selection and Sampling Schedule

A sampling design employing both targeted and randomly-selected sites was chosen by the City to best meet the purposes of this study. Targeted sites provided an assessment of specific locations of interest, particularly those downstream of particular developed or newly developing areas. Random sites, selected using a probability-based sampling design similar to that of the MBSS, allowed for an unbiased, overall assessment of conditions typical of streams throughout the City.

Ten randomly-selected stream monitoring sites were chosen along streams within the City of Gaithersburg. In order to choose sites randomly, the streams in the City's geographic information system (GIS) stream reach file were first divided into two main watersheds based on drainage patterns – Muddy Branch and Great Seneca Tributary. Within the City of Gaithersburg, Muddy Branch and its tributaries had a total of 14.0 stream miles, and Great Seneca Tributary watershed had a total of 12.6 stream miles, including Long Draught Branch (4.0 stream miles). Within the City, the total land areas of each watershed were as follows: 2980 acres in Muddy Branch and 3413 acres in Great Seneca Tributary, including the area draining to Long Draught Branch (1272 acres). Figure 2-1 shows Gaithersburg streams and watersheds in the context of the broader regional stream network and watersheds. The watershed boundaries shown here are the Maryland 8-digit watershed and 12-digit subwatershed delineations.

To ensure proportional coverage of each watershed, the number of sample points allocated to each watershed was based on the proportion of stream miles in each watershed. In this case, the total number of stream miles was nearly evenly divided between the Muddy Branch and Great Seneca Tributary watersheds, indicating that five sites should be placed in each. A FORTRAN-based program was used to randomly select locations along the streams in each of these two watersheds, and then these points were plotted in the GIS. To account for potential sampleability problems, extra candidate sites were chosen in the random draw within each watershed. Potential sites were numbered based on a random pick order so that, during field reconnaissance to determine sampleability, sites were visited in the order that they were chosen. Of the total 30 candidate sites (15 in Muddy Branch watershed, and 15 in Great Seneca Tributary watershed), the target was a final list of ten monitoring sites for sampling (five per watershed).

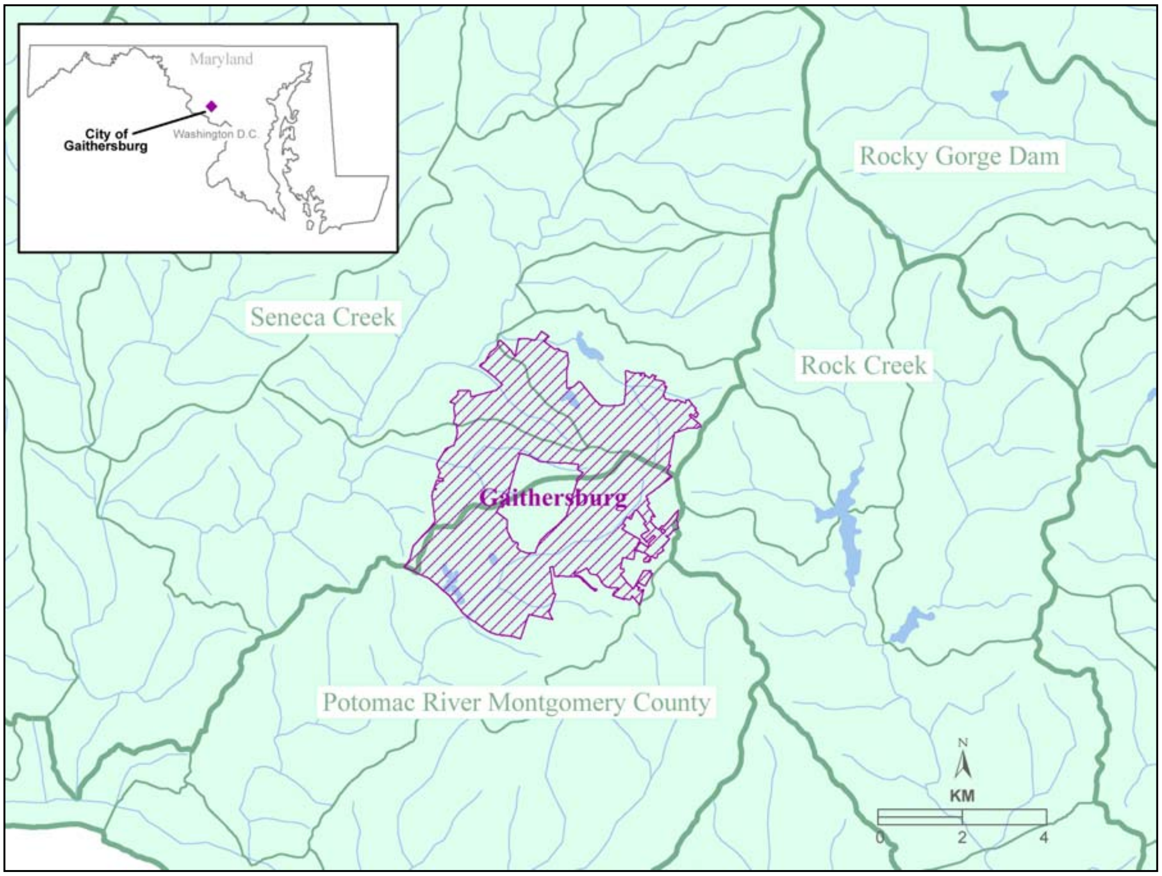


Figure 2-1. Streams and watershed boundaries in the vicinity of Gaithersburg, Maryland. Bold lines are the boundaries of Maryland 8-digit watersheds; narrow lines indicate 12-digit subwatersheds.

During November 2001, field staff conducted reconnaissance visits to determine whether candidate site locations would be suitable for sampling, based on logistical considerations such as stream size, depth, dry streambeds, landowner permission, and safety. Each potential site was visited in numerical order. If a site was deemed not sampleable, the next site on the list was visited until the quota of five sites in each of the watersheds was met. A handheld global positioning system (GPS) unit was used to navigate to the coordinates of each site. The coordinates represented the mid-point of each 75-meter sample segment, and if the site was determined to be sampleable, the mid-point was marked with flagging tape. Photos were taken to document stream conditions.

In addition to these ten randomly selected sites, five initial targeted sites were chosen based on recommendations from City of Gaithersburg staff. These targeted sites were selected to evaluate conditions in the vicinity of several new construction sites and other areas of special concern to the City. These targeted sites were visited during the November field reconnaissance to determine sampleability.

Site names were assigned to reflect site type and/or watershed location. Randomly selected sites in Muddy Branch watershed begin with “MB” and those in Great Seneca Tributary watershed begin with “GST”, followed by a number corresponding to the order the candidate site was selected in the random draw. City-targeted sites begin with “CS”, followed by a number designating the order in which these sites were visited during field reconnaissance.

Prior to the spring sampling season, the City requested that one of the random sites (GST 5) be moved slightly downstream to better characterize conditions below the proposed Hidden Creek development. This new location was designated a targeted site (CS 8), since its selection no longer qualified as random. An additional targeted site (CS 7) was added prior to spring sampling. Habitat sampling for these two new sites was conducted during spring. These changes and additions brought the total number of targeted sites to seven, and the total number of random sites to nine (five in Muddy Branch and four in Great Seneca Tributary), as shown in Figure 2-2 and listed in Table 2-1.

Table 2-1. City of Gaithersburg 2001-2002 stream assessment sites

Watershed	Randomly Selected Sites		Targeted Sites	
Muddy Branch	MB 1	Mainstem of Muddy Branch, east of MD-119 and Lake Varuna. Access by School Rd. to Timberbrook apartments, follow hiker/biker trail north.	CS 1	Mainstem of Muddy Branch in Malcolm King Park below Brighton weir. Access by Plum Grove Rd.
	MB 2	Mainstem of Muddy Branch in Lakelands, south of Lake Varuna. Access by Gentlewood St. and Stonemason Dr.	CS 2	Tributary to Muddy Branch, Edgewood Rd. off Westland Rd.
	MB 3	Unnamed tributary to Muddy Branch behind Brighton Village apartments. West Side Dr. off Muddy Branch Rd.	CS 7	Tributary to Muddy Branch downstream of Lake Placid. Access by Still Creek Lane, Lakelands
	MB 5	Mainstem of Muddy Branch in Lakelands, east of Lake Placid. Access by Still Creek Lane.		
	MB 10	Mainstem Muddy Branch above I-270. In Morris Park, access by Summit Hall Rd.		

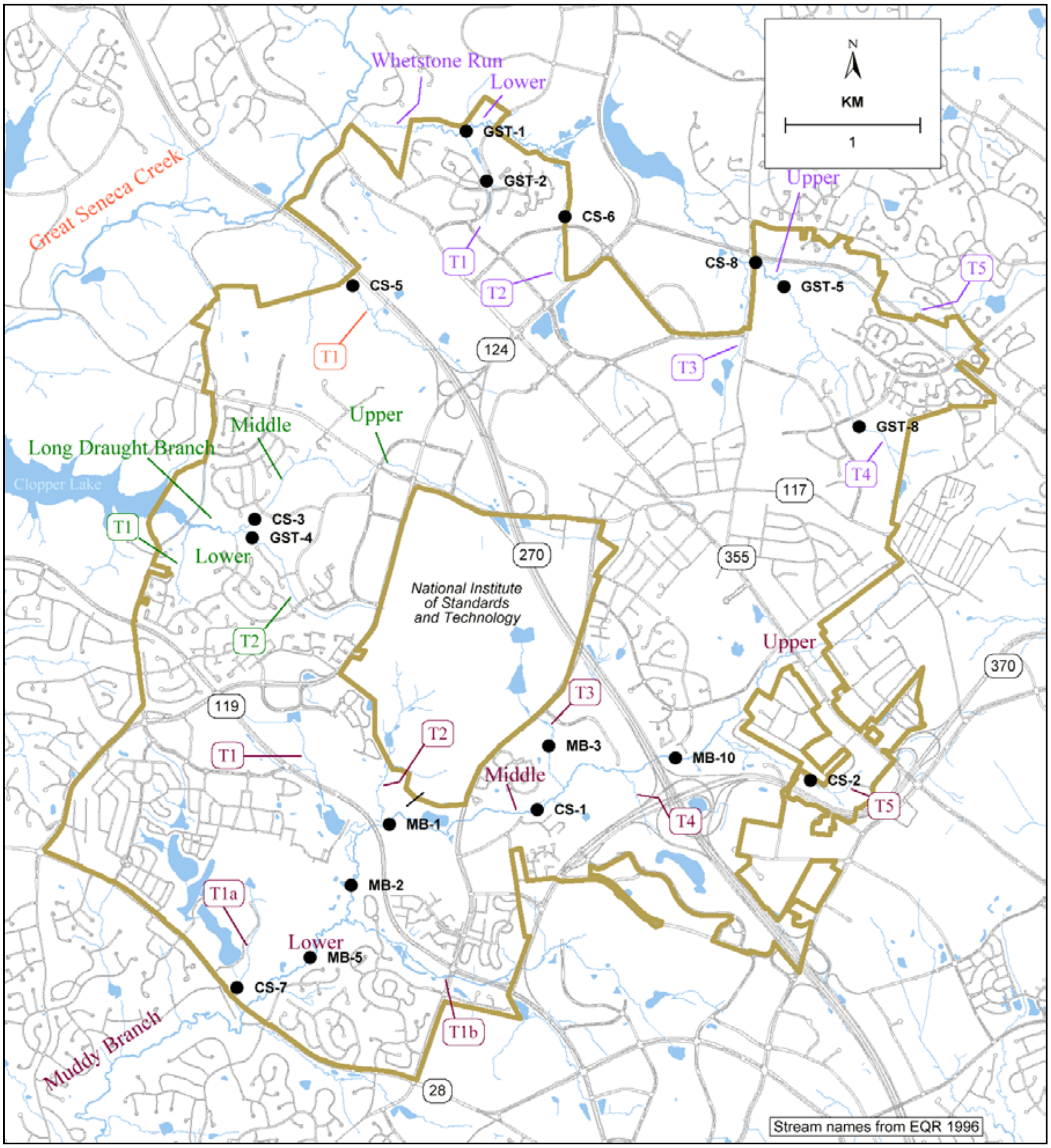


Figure 2-2. City of Gaithersburg 2001-2002 random and city-targeted sample locations

Table 2-1. (Continued)				
Watershed	**Randomly Selected Sites**		**Targeted Sites**	
Great Seneca	GST 1	Unnamed Tributary to Great Seneca Creek north of Knoll Mist Lane. Off Watkins Mill Rd., by Blohm Park, behind Pavilion	CS 3	Southern Tributary to Long Draught Branch east of Clopper Lake. Below Rabbitt Rd.
	GST 2	Unnamed Tributary to Great Seneca Creek west of Watkins Mill Rd. Access by Knoll Mist Lane.	CS 5	Unnamed Tributary to Great Seneca Creek near 270. Behind MVA and train tracks.
	GST 4	Southern Tributary to Long Draught Branch east of Clopper Lake. Access from Solitare Ct	CS 6	Unnamed Tributary to Great Seneca Creek, below Christopher Rd. Downstream of Lakeforest Mall.
	GST 5*	Tributary to Great Seneca Creek upstream of Lake Whetstone. Access by Forest Oak Middle school.	CS 8	Tributary to Great Seneca Creek upstream of Lake Whetstone, Hidden Creek. Access from Midcounty Hwy and Summit Ave.
	GST 8	Tributary to Great Seneca Creek in Kelley Park. Access by Victory Farm Rd.		

* Site moved to CS 8 in spring

Field sampling at each of the random and targeted sites occurred three times during the course of the study. Table 2-2 lists the sampling periods, the actual dates when sampling took place, and the types of data collected during each period. Benthic and fish sampling took place within the appropriate spring and summer index periods specified by the MBSS protocols.

Table 2-2. City of Gaithersburg 2001-2002 stream assessment sampling schedule

Sampling Period	Dates	Data Collected
Fall	December 10 - 19, 2001	Physical Habitat: Longitudinal and Cross-Sectional Profiles Wolman Pebble Counts Qualitative Habitat Assessment Using Montgomery County Methods Water Quality
Spring	March 5 - 6, 2002	Physical Habitat: Riparian Zone/Adjacent Land Use Characterization Qualitative Habitat Assessment Using Montgomery County Methods Benthic Macroinvertebrate Sampling Water Quality
Summer	June 18 - 26, 2002	Physical Habitat: Qualitative Habitat Assessment Using MBSS Methods Stream Characterization Bank and Channel Stability Fish Sampling Amphibian and Reptile Sampling Water Quality

2.1.2 Physical Habitat Assessment

Drawing from both the MBSS and Montgomery County assessment methods, several quantitative geomorphological techniques were employed to characterize the stream channel, flow conditions, substrate, riparian areas, and instream habitat at each monitoring site.

Cross sections were surveyed to document the present-day stream profile. At each site, a cross-sectional profile was surveyed using a Topcon dumpy level, tripod, and stadia rod. The tripod and level were set up several feet back from the bank so that an accurate measure of relative elevations could be taken. A measuring tape was stretched across the channel a few feet beyond bankfull height to ensure that the whole stream channel was being surveyed. Elevations were measured at 20 equally spaced intervals across the stream channel, starting from the left bank to the right, looking downstream. Metal rods were placed in the ground to mark the end-points of each cross-section to ensure that the same cross-section can be measured again, and a large nail was placed in the base of a nearby tree at each site and clearly marked to serve as a benchmark for future measurement. Water surface slope was also measured at each site by surveying relative elevations and horizontal distances between two points at the lower (0-meter) and upper (75-meter) ends of the sample segment. Measurements were taken at the water surface. Both the cross-section and the water surface slope were measured during fall sampling.

A Marsh-McBirney Flo-Mate electronic velocity meter was used to measure the water's velocity and create a velocity/depth profile. Water velocities were recorded at the cross-section in the fall, and at an area of the stream that presented the best example of laminar flow in the summer, to ensure accurate discharge rates. The velocity sensor was set at 6/10 of the water's depth using a top-setting wading rod. Water depths at each measurement and distances between measurements were recorded in the field and were later combined with the velocity readings to calculate stream discharge at each site.

The stream substrate was characterized by performing a modified Wolman pebble count, as described in Rosgen (1996). In this procedure, the percentage of riffles and pools within each site were estimated. Then, ten transects were proportionally divided between the riffle and pool locations. For example, if a segment was estimated to have 70% riffle and 30% pool habitat, then seven transects would be in riffle sections and three in pool sections. Each of the transects was divided into 10 equally spaced segments in which particles were selected using the "first blind touch" technique to avoid biasing the sample. The intermediate axis of each observed particle was measured and recorded on a field data sheet. Cumulative totals for each particle size, in addition to the cumulative percentage of particles, were then plotted in a log-normal graph. Finally, the representative median particle diameter, or the D50 index diameter, was read from the plot. Wolman pebble counts were performed in the fall.

Bank pins were installed and monitored to measure bank erosion rates at each site. A three-foot steel rod was driven perpendicularly into the bank at the approximate bankfull height, leaving approximately a foot exposed. The exposed end of this bank pin was entirely covered in orange spray paint to mark the edge of the bank at the time of placement. Bank pins were installed during fall sampling, and were placed in an area where there were no bends, blockages, or unusual occurrences in the stream channel. These bank pins were then examined during subsequent visits to measure the amount of unpainted rod, indicating the rate of bank erosion.

A longitudinal profile was developed for each 75-meter sample segment by measuring the length of each consecutive habitat type (i.e., riffle, pool, or run). Also, at the end of each habitat type, the percentage of wetted channel width to channel width was estimated. The wetted width was the linear distance between the water line on the left bank to the water line on the right bank, while the channel width was the distance between banks at an elevation estimated to represent bankfull conditions. In addition, the maximum water depth and depth of deposition were recorded in each pool. This information is useful for determining stream habitat types, sediment load, and general stream character. The longitudinal profile was surveyed during the fall sampling season.

Stream channel measures were also taken at four points within the 75-meter stream segment at each site, one each at the zero meter mark, the 25-meter mark, the 50-meter mark, and the 75-meter mark to characterize habitat. At these cross-sections, the wetted width, channel width, and thalweg depths (i.e., deepest and fastest flowing part of the channel) were measured and recorded. This was done during the summer sampling season. In addition, observations on the type of bank material, as well as the vegetative type covering each bank were noted. Percent estimates were also made for the total bank height covered by vegetation for both banks, as well as the amount of canopy cover in the middle of the cross section. This was done during the fall sampling season.

In addition to these quantitative techniques for evaluating the stream channel, a qualitative habitat assessment for riffle/run prevalent streams was used to evaluate physical habitat at each site using rapid assessment protocols. Evaluations conducted during the fall and spring sampling seasons followed Montgomery County sampling protocols (Van Ness et al. 1997), which are based on earlier protocols, (Plafkin et al. 1989, Barbour and Stribling 1994). Parameters included instream cover, epifaunal substrate, embeddedness, channel alteration, sediment deposition, frequency of riffles, channel flow status, bank vegetative protection (left and right), bank stability (left and right), and riparian vegetative zone (left and right). In addition, the riparian zone and adjacent land use, as well as the extent and types of channelization, were characterized in more detail.

In the summer, another qualitative habitat assessment was conducted following MBSS protocols (Kazyak 2001), which involves slightly different parameters. These parameters include instream habitat, epifaunal substrate, velocity/depth diversity, pool/glide/eddy quality, riffle/run quality, embeddedness, and shading. MBSS methods were also used to evaluate bank erosion, channel bar formation, and evidence of channelization. Both programs' sampling protocols were employed, as requested by the City, to provide consistency with both County and state data from other locations.

2.1.3 Water Quality

Field measurements of water temperature, dissolved oxygen, conductivity, turbidity, and pH were taken at each site during each sampling period. A handheld YSI multiparameter instrument was calibrated daily and used for each sampling event. Upon arrival at each site, the YSI was placed in a location that had flowing water for the most accurate reading. This location was approached from the downstream side to avoid disturbing sediments that could influence the results of the sample.

2.1.4 Benthic Macroinvertebrates

Following MBSS protocols, benthic macroinvertebrate sampling took place during the spring sampling period. At each site, a 600-micron "D" net was used to collect organisms from habitats likely to support the greatest taxonomic diversity (riffle habitats where possible). Sampling involved placing the net downstream, gently rubbing surficial substrates by hand to dislodge organisms, and disrupting deeper substrates using vigorous foot action. Each dip of the net was used to collect organisms from a 1-2 square-foot area, until a total of approximately 2.0 m^2 (20 square feet) of combined substrates was sampled. Organisms collected from a total of 20 dips were composited into a single sample and then preserved in 70% ethanol.

In the laboratory, the preserved sample was transferred to a gridded pan and organisms were picked from randomly selected grid cells until the cell that contained the 100th individual (if possible) was completely picked. Some samples had fewer than 100 individuals. All of the macroinvertebrates in the 100-organism subsamples were identified to genus, or lowest practicable taxon, in the laboratory. A complete description of laboratory protocols can be found in Boward and Friedman (2000).

2.1.5 Fish

Fish were sampled during the summer sampling period using double-pass electrofishing techniques within the 75-meter stream segments. Block nets were placed at each end of the segment to prevent fish movement, and direct current electrofishing units were used to temporarily stun fish within the segment. An attempt was made to thoroughly fish each segment on each pass, sampling all habitat within the entire stream segment. A consistent effort was applied over the two passes.

Captured fish were stored in livewells and identified in the field to species, weighed in aggregate, counted, and released. Any individuals that could not be identified to species were retained for laboratory confirmation. For each pass, all gamefish (i.e., trout, bass, walleye, pike, chain pickerel, and striped bass) were measured for total length. For each species, unusual occurrences of visible external pathologies or anomalies were noted.

2.1.6 Amphibians and Reptiles

At each site, amphibians and reptiles found during the course of electrofishing and other activities were captured, identified, and recorded. Individuals were identified to species when possible.

At ten of the stream sampling monitoring sites, additional sampling for salamanders was undertaken as part of a statewide investigation that Versar is conducting in cooperation with the U.S. Geological Survey (USGS). Systematic searches were performed in two 15-meter transects, as well as two 2-meter by 2-meter quadrats following the methods in Southerland et al. (2001). Transect and quadrat searches were performed half in the stream (wetted) and half out (dry) to ensure that both larval and adult salamanders could be captured. Transects were sampled by turning over the first layer of habitat (rocks, logs, leaves), while the quadrats were sampled down several layers, to ensure that all species could potentially be collected. In addition, a second pass was performed on the transect that yielded the largest catch to derive a population estimate, based on depletion. The number of rocks turned over and sampling time were recorded to determine effort. Individual larvae and adults were identified to species, and their total length was measured.

2.1.7 Data Management

The field crew used standardized pre-printed data forms developed to ensure that all data for each site were recorded and standard units of measure were used. MBSS data QA/QC procedures (Kazyak 2001) were strictly adhered to. A custom database application (written in Microsoft Access) was used for data entry, in which the input module was designed to match each of the field data sheets. Data were independently entered into two separate databases and compared using a computer program as a quality-control procedure. Differences between the two databases were resolved from the original data sheets or in consultation with the field crew.

2.1.8 Analysis of Biological Data

Indices of Biotic Integrity (IBI; Karr et al. 1986) for fish and benthic macroinvertebrates were calculated for each site. The IBI is a widely accepted multi-metric indicator used for biological assessment, recommended by EPA (Barbour et al. 1997) and employed by many state and local water quality programs nationwide. The IBI compares the condition of biological assemblages to that of a least-disturbed reference condition (ideally, a stream with conditions only minimally impacted by human activities). Individual metrics quantitatively describe attributes of the biological community; a series of these metrics are scored and combined into a single index. Originally developed for Midwestern fish communities; the IBI approach has been adapted for a variety of regions and taxonomic groups, including freshwater macroinvertebrates.

For this assessment, fish and macroinvertebrate IBIs were calculated using protocols developed by the Maryland Biological Stream Survey (Roth et al. 1998, 2000; Stribling et al. 1998). Each IBI was developed with specific regional formulations; the appropriate ones were used for sites in the Gaithersburg survey – the Eastern Piedmont IBI for fish and the non-Coastal Plain IBI for benthos. Individual metrics for the IBI were scored 1, 3, or 5 based on comparison with the distribution of metric values at regional reference sites. See Tables 2-3 through 2-7 for scoring criteria and metric descriptions. Final IBI scores are the mean value of the individual metric scores, and thus range from 1 to 5. A score of 3 or greater is considered comparable to reference site conditions, while scores less than 3 differ significantly from reference conditions. Numerical scores are reported along with the corresponding narrative rating (e.g., good, fair, poor, very poor) comparing the site's biological integrity to what would be expected at a relatively unimpacted stream for the region. Table 2-3 describes the MBSS IBI scores in detail.

Table 2-3. Narrative descriptions of stream biological integrity associated with each of the MBSS IBI categories (Roth et al. 2000)

Good	IBI score 4.0 - 5.0	Comparable to reference streams considered to be minimally impacted. On average, biological metrics fall within the upper 50% of reference site conditions.
Fair	IBI score 3.0 - 3.9	Comparable to reference conditions, but some aspects of biological integrity may not resemble the qualities of these minimally impacted streams. On average, biological metrics fall within the lower portion of the range of reference sites (10th to 50th percentile).
Poor	IBI score 2.0 - 2.9	Significant deviation from reference conditions, with many aspects of biological integrity not resembling the qualities of these minimally impacted streams, indicating degradation. On average, biological metrics fall below the 10th percentile of reference site values.
Very Poor	IBI score 1.0 - 1.9	Strong deviation from reference conditions, with most aspects of biological integrity not resembling the qualities of these minimally impacted streams, indicating severe degradation. On average, biological metrics fall below the 10th percentile of reference site values; most or all metrics are below this level.

To aid in assessing stream condition, other biological parameters based on benthic and fish communities were also examined. Some commonly used benthic measures, useful in detecting biological impacts, include taxa richness and the number of Ephemeroptera, Plecoptera, and Tricoptera (EPT) taxa. A large number of EPT taxa (mayflies, stoneflies, and caddisflies) generally indicates better water quality and habitat condition. Indicators of fish community condition include species richness, abundance, and percent tolerant individuals. While the benthic and fish IBIs integrate much of this and other information into a composite index, it is often useful to examine individual values for other parameters.

Table 2-4. Metrics and scoring criteria for the MBSS Fish IBI, Eastern Piedmont region. Some metrics[a] are adjusted for site-specific catchment area, based on linear relationships [b] between the metric and log(catchment area) in acres. From Roth et al. (2000).

	Scoring criteria 5	3	1
Eastern Piedmont			
Number of native species[a]	Criteria vary with stream size (see below)		
Number of benthic fish species[a]	Criteria vary with stream size (see below)		
Number of intolerant species[a]	Criteria vary with stream size (see below)		
Percent tolerant fish	≤ 41	$41 < x \leq 65$	> 65
Percent abundance of dominant species	≤ 30	$30 < x \leq 52$	> 52
Percent generalists, omnivores, and invertivores	≤ 86	$86 < x \leq 99.7$	> 99.7
Number of individuals per square meter	≥ 0.81	$0.35 \leq x < 0.81$	< 0.35
Biomass per square meter	≥ 8.0	$3.7 \leq x < 8.0$	< 3.7
Percent lithophilic spawners	≥ 62	$22 \leq x < 62$	< 22

[a] Adjusted value = observed value/expected value, where expected value = m * log(catchment area in acres) + b.

	Scoring criteria 5	3	1
Eastern Piedmont			
Number of native species – Adjusted value	≥ 1.02	$0.56 \leq x < 1.02$	< 0.56
Number of benthic fish species – Adjusted value	≥ 0.99	$0.50 \leq x < 0.99$	< 0.50
Number of intolerant species – Adjusted value	≥ 0.59	$0.18 \leq x < 0.59$	< 0.18

[b] Slope and intercept values for selected metrics, based on linear regression relationships between metric and log(catchment area) in acres

	Slope (m)	Intercept (b)
Eastern Piedmont		
Number of native species	5.5701	-8.1135
Number of benthic fish species	1.3245	-2.6437
Number of intolerant species	4.4052	-8.8991

Table 2-5. Description of Maryland Biological Stream Survey Fish IBI metrics for the Eastern Piedmont region. From Roth et al (2000).

Number of native species (adjusted for catchment area) - Total number of native fish species; adjusted for watershed area Fishes were classified as native or introduced to Chesapeake Bay or Youghiogheny/Ohio River drainage.

Number of benthic fish species (adjusted for catchment area) - The number of fish species that reside primarily on the stream bottom, adjusted for watershed area. Benthic fishes include all darters (*Etheostoma* spp., *Perca* spp.), sculpins (*Cottus* spp.), madtoms (*Noturus* spp.), and lampreys (*Petromyzon* spp., *Lampetra* spp.).

Number of intolerant species (adjusted for catchment area) - The number of fish species rated as intolerant of anthropogenic stress, adjusted for watershed area. Tolerance ratings (intolerant, tolerant) were based on statewide analysis comparing species occurrences with presence/absence of anthropogenic stressors.

Percentage tolerant fish - Percentage of individuals rated as tolerant to anthropogenic stress.

Percentage abundance of dominant species - Percentage of individuals within the single most abundant (dominant) species at a site.

Percentage generalists, omnivores, and invertivores - Percentage of individuals classified into the trophic groups of generalist, omnivore, or invertivore; these are the most general of all feeding habits. Invertivores eat insects and other invertebrates including crustaceans, mollusks, and worms. Omnivores consume two or more food types (insects, invertebrates other than insects, fish, plankton, algae, vascular plants, and detritus) with the exception of the combination of invertebrates and fishes. Generalists eat both invertebrates and fishes but not other food items.

Number of individuals per square meter - The number of individuals captured at a site, divided by the surface area fished. Surface area was computed as length of stream fished (usually 75 m) multiplied by average stream width.

Biomass (g) per square meter - Total mass in grams of fish captured at a site, divided by the surface area fished.

Percentage lithophilic spawners - Percentage of individuals reported to use rock substrates for spawning.

Table 2-6. Metrics scoring criteria for the Maryland Biological Stream Survey benthic IBI, non-Coastal Plain region. From Stribling et al. (1998).

	Scoring Criteria		
Non-Coastal Plain	**5**	**3**	**1**
Total taxa	> 22	16 < x < 22	< 16
EPT taxa	> 12	5 < x < 12	< 5
Ephemeroptera taxa	> 4	2 < x < 4	< 2
Diptera taxa	> 9	6 < x < 9	< 6
% Ephemeroptera	> 20.3	5.7 < x < 20.3	< 5.7
% Tanytarsini	> 4.8	0.0 < x < 4.8	< 0.0
Intolerant taxa	> 8	3 < x < 8	< 3
% tolerant	< 11.8	11.8 < x < 48.0	> 48.0
% collectors	> 31.0	13.5 < x < 31.0	< 13.5

Table 2-7. Description of Maryland Biological Stream Survey benthic IBI metrics for the non-Coastal Plain region. From Stribling et al. (1998).

Total number of taxa - Total number of benthic taxa in the sample. This measures the overall variety of the macroinvertebrate assemblage.

Number of EPT taxa - Number of taxa in the insect orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies).

Number of Ephemeroptera taxa - Number of mayfly taxa.

Number of Diptera taxa - Number of "true" fly taxa, including midges.

Percentage Ephemeroptera - Percentage of mayfly individuals in the sample.

Percentage Tanytarsini - Percentage of Tantarsini midges to total fauna in the sample.

Number of intolerant taxa - Number of taxa considered to be sensitive to perturbation (Hilsenhoff values 0-3).

Percentage tolerant - Percentage of individuals in taxa considered tolerant of perturbation (tolerance values 7-10).

Percentage collectors - Percentage of individuals that feed on detrital deposits or loose surface films.

2.1.9 LAND USE ANALYSIS

To provide added context for interpreting results, land uses within catchments upstream of sample sites were derived using GIS techniques. Individual catchments upstream of each sample site were digitized using topographic lines from digital topographic maps (1:24,000 scale). The catchment boundaries were then intersected with land use/land cover data from the Federal Multi-Resolution Land Characteristics (MRLC) digital data set, Version 98-04 (MRLC 1998). This national land cover data set was developed by a federal agency consortium, using data primarily from Landsat 1991-93 Thematic Mapper satellite images at a resolution of 30 x 30 m pixels. Using GIS, the area within each catchment was calculated as was the percentage of area within each watershed represented by each type of land use. Land use types were grouped into the following major classes: urban land, agriculture, forest, wetlands, and water.

2.2 STREAM ASSESSMENT RESULTS

Land use characterizations set the stage for interpreting the stream assessment results. Individual results of the physical habitat assessments, water quality sampling, and biological assessments are presented below. Results for all individual random and targeted sample sites are provided. In addition, mean values have been calculated from data at the randomly selected sites. This sample mean provides an unbiased estimate of the mean condition for entire population of streams in the City of Gaithersburg.

2.2.1 Land Use

The catchments upstream of each site were digitized using a GIS and overlaid on MRLC land use data**.** From this, land use statistics were calculated and are presented in Table 2-8 and Figure 2-3.

Table 2-8. Percentage of land use types in the catchment area upstream of each site sampled in the City of Gaithersburg 2001-2002 stream assessment

	Site	Urban (%)	Agriculture (%)	Forest (%)	Wetlands (%)	Water (%)	Catchment Area (acres)
Random	MB1	55.0	26.3	17.1	0.1	1.5	2247
	MB2	43.3	36.4	18.5	0.2	1.6	2298
	MB3	47.3	36.5	13.8	0.2	2.2	468
	MB5	37.9	43.4	17.2	0.2	1.4	4169
	MB10	60.2	21.4	17.2	0.0	1.2	1007
	GST1	56.9	24.3	15.9	0.8	1.9	2716
	GST2	61.5	36.6	1.9	0.0	0.0	115
	GST4	49.8	34.1	16.0	0.1	0.0	250
	GST8	44.1	7.2	47.8	0.1	0.7	190
	Mean *	50.7	29.6	18.4	0.2	1.2	1496

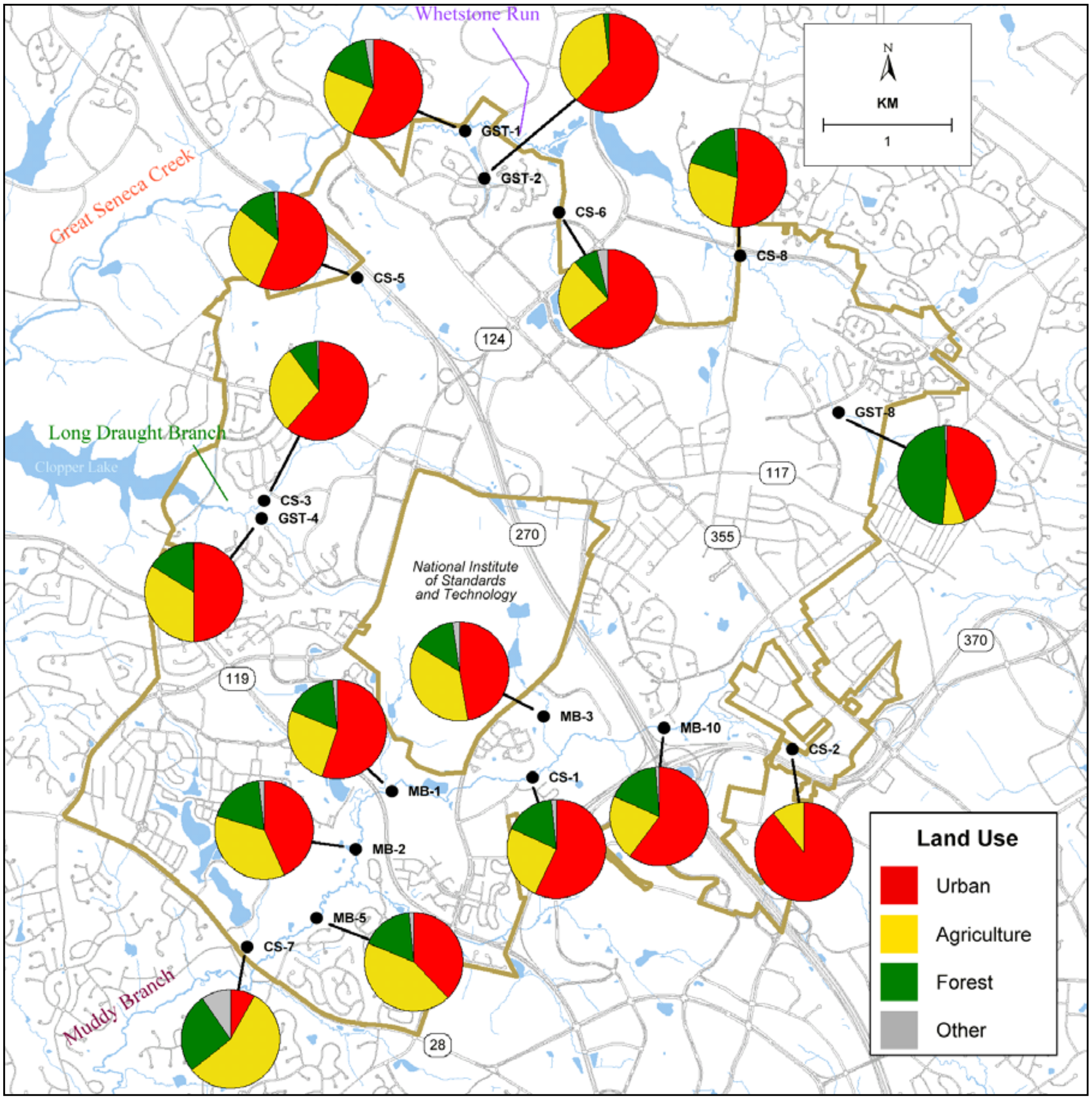


Figure 2-3. Proportions of land use types in the catchment area upstream of each study site. Source data reflect land uses from the early 1990s.

Table 2-8 (Continued)							
	Site	**Urban (%)**	**Agriculture (%)**	**Forest (%)**	**Wetlands (%)**	**Water (%)**	**Catchment Area (acres)**
Targeted	CS1	57.1	24.7	16.6	0.1	1.5	1988
	CS2	89.4	10.6	0.0	0.0	0.0	76
	CS3	61.3	28.7	9.3	0.6	0.1	785
	CS5	56.4	29.5	12.7	0.4	1.0	472
	CS6	64.3	24.1	8.0	0.2	3.5	289
	CS7	8.1	56.2	26.2	0.6	9.0	391
	CS8	52.0	28.0	18.9	0.6	0.3	1295

* Mean value for all randomly selected sites; represents the estimated average condition for all streams Citywide.

These data reflect the prevalence of developed, urban lands throughout much of Gaithersburg. The mean percentage of urban land, by catchment, was 50.7%. The agriculture class (which ranged from 7 to 56%) also includes open urban land such as parks and large lawns. Note that except for site CS-7, the predominant land use at all sites is urban, a class that includes high- and low-density residential area as well as commercial/industrial uses. Because the MRLC is based on source data from the early 1990s, it is likely that these numbers may even under-estimate urban land coverage, given the rapid rate of recent development within the City. Over the past decade, the most significant land use changes have occurred in the southwestern portion of the City. Such areas as Kentlands, Lakelands, Quince Orchard Park, Washingtonian Woods, and Washingtonian have undergone extensive development. In addition, other areas throughout the City have also experienced land use changes. Such areas include Asbury, Crown Pointe Corporate Center, north and south of Midcounty Highway, north of Pheasant Run Drive, and Mission Hills. In fact, urban land use has probably increased at all sites including MB-2, MB-5, and CS-7, which are located downstream of the Lakelands and Kentlands developments.

2.2.2 Physical Habitat Assessment

Physical habitat data provide descriptive characterizations of current conditions observed in Gaithersburg streams as well as useful information for assessing stream quality.

2.2.2.1 Qualitative Habitat Assessment

As noted above, qualitative physical habitat scores were recorded using Montgomery County methods during both the fall and spring sampling periods. MBSS methods were used in the summer. These two methods are quite similar, but are slightly different in several scoring areas. While general comparisons between the two are acceptable at the overall narrative ranking level, individual scores should not be compared due to the slight differences between methods. Both methods provide an ecological indicator of stream habitat quality by evaluating multiple factors important to biota.

The Montgomery County qualitative habitat assessment method (Van Ness et al. 1997, Barbour and Stribling 1994) rates streams on a 0-200 scale as follows:

- Optimal: 166 to 200
- Sub-Optimal: 113 to 153
- Marginal: 60 to 100
- Poor: 0 to 47

Values falling between these category boundaries represent an intermediate condition (for example, a score of 55 would represent Marginal to Poor condition).

For fall sampling, total scores ranged from 71 to 141, with all sites falling in the Marginal and Sub-Optimal categories (Figure 2-4, Table 2-9). Table 2-9 shows results for individual parameters and total scores. The mean score for the randomly selected sites was 103.7 (Marginal to Sub-Optimal). Site GST 2 scored the lowest, with a score of 71 (Marginal). It also scored the lowest for several individual metrics, including channel alteration, bank vegetative protection (left bank), bank stability (left bank), and riparian buffer width (left bank). Site MB 1 received the highest qualitative habitat score (141; rated Sub-Optimal) and also scored the highest for the following individual metrics: embeddedness, sediment deposition, bank vegetative protection (left bank), bank stability (left bank), and riparian buffer width (left bank).

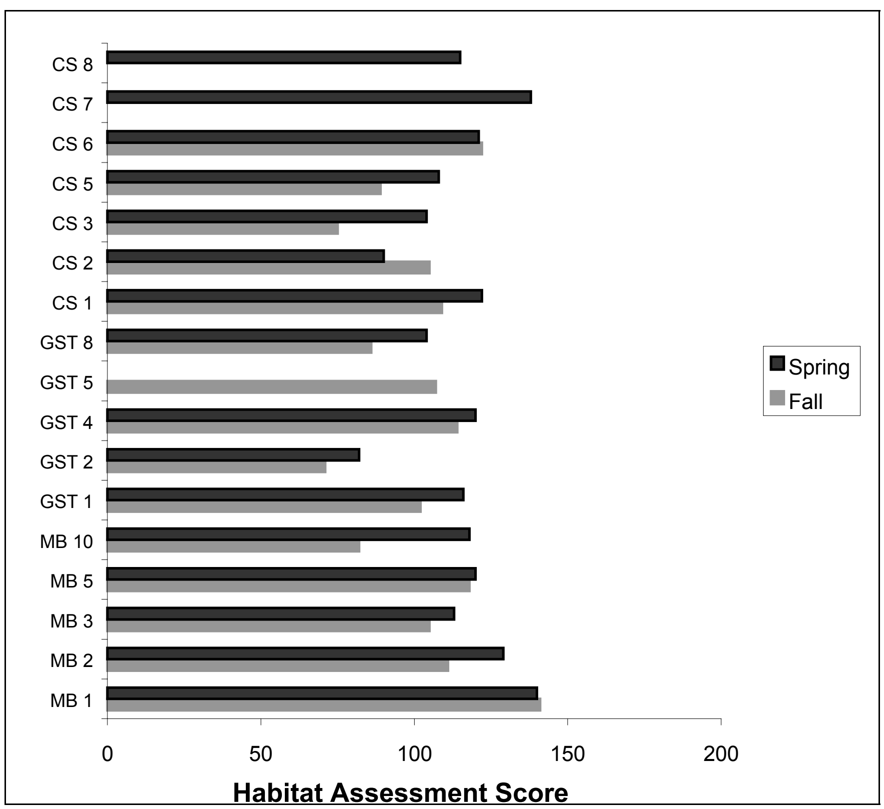


Figure 2-4.   Qualitative habitat indicator, Montgomery County protocol, City of Gaithersburg 2001-2002 sampling sites

	Station	Instream Cover (0-20)	Epifaunal Substrate (0-20)	Embedded-ness (0-20)	Channel Alteration (0-20)	Sediment Deposition (0-20)	Frequency of Riffles (0-20)	Channel Flow Status (0-20)	Bank Veg. Protection Left (0-10)	Bank Veg. Protection Right (0-10)	Bank Stability Left (0-10)	Bank Stability Right (0-10)	Riparian Width Left (0-10)	Riparian Width Right (0-10)	Total Habitat Score (0-200)
Random	MB 1	15	13	15	14	13	13	14	8	5	8	6	9	8	141
	MB 2	13	11	13	9	8	12	9	7	7	5	7	1	9	111
	MB 3	10	8	14	12	13	7	13	4	3	4	6	9	2	105
	MB 5	15	10	14	17	7	10	9	5	5	5	6	9	6	118
	MB 10	11	8	6	7	6	6	8	3	2	7	7	2	9	82
	GST 1	10	12	7	18	12	14	16	4	2	1	2	2	2	102
	GST 2	7	11	14	2	9	5	8	3	4	1	4	1	2	71
	GST 4	11	16	11	10	9	16	9	6	6	4	2	9	5	114
	GST 5	14	12	12	14	7	12	8	4	5	3	5	5	6	107
	GST 8	6	10	11	6	12	5	14	5	5	5	5	1	1	86
	Mean	11.2	11.1	11.7	10.9	9.6	10.0	10.8	4.9	4.4	4.3	5.0	4.8	5.0	103.7
Targeted	CS 1	17	14	15	9	5	12	7	5	4	3	3	6	9	109
	CS 2	12	10	9	13	6	10	8	5	4	5	5	9	9	105
	CS 3	5	6	6	6	12	4	16	6	6	3	3	1	1	75
	CS 5	10	9	11	17	7	7	6	4	2	2	2	6	6	89
	CS 6	13	14	12	8	10	16	16	5	6	7	6	3	6	122

Table 2-9. City of Gaithersburg fall physical habitat sampling results for rapid habitat parameters, Montgomery County protocol

In spring, qualitative habitat scores ranged from 82 to 140, again with all sites falling in the Marginal and Sub-Optimal categories (Figure 2-4, Table 2-10). Table 2-10 shows individual parameter results, including scores for the two new sites added in spring, CS 7 and CS 8. The mean total score for the randomly selected sites was 115.7 (Sub-Optimal), which was slightly higher than in the Fall. Site GST 2 again had the lowest score (82, Marginal). It also scored the lowest for instream cover (7 out of 20), channel alteration (6), bank vegetative protection (left bank, 3), and bank stability (left and right banks, 1). Site MB 1 again received the highest score (140; Sub-Optimal) and scored the highest for the following metrics: instream cover, channel alteration, and riparian buffer width (left bank). As shown (Figure 2-4), indicator values for most sites were similar during fall and spring sampling.

During the summer sampling period, MBSS methods were used for qualitative habitat assessment. Results for individual parameters are shown in Table 2-11. Instream habitat, a parameter describing the availability of logs, rocks, and other habitat structures, is often an important indicator of conditions for fish and other biota. Instream habitat scores ranged from 6 (marginal) to 16 (optimal) out of 20. Three sites scored 16, including MB 5, CS 1, and CS 6.

The amount of shading provided by overhead vegetation is also evaluated in the MBSS qualitative habitat sampling methods. Shade is an important factor for small streams because it moderates water temperatures on hot summer days, reduces algal growth, and provides cover and food in the form of roots and branches, and leaves, respectively. A broad range of shade conditions was observed. The highest shading percentage was observed at site GST 8 (98%), followed by CS 2 (97%). The lowest percentage was at site CS 3 (20%).

The MBSS Physical Habitat Index (PHI; Hall et al. 1999) was calculated for the stream monitoring sites based in data collected during the summer. The provisional PHI is a measure of several different parameters measured at each monitoring site and yields an overall evaluation of habitat condition. This indicator rates streams on a 0-100 scale as follows:

- Good: 72 to 100
- Fair: 42 to 71.9
- Poor: 12 to 41.9
- Very Poor: 0 to 11.9

PHI results are mapped in Figure 2-5. Scores ranged from 8.5 (Very Poor) to 84.2 (Good) (Figure 2-6, Table 2-11). The mean PHI score at random sites was 42.8 (Fair). Interestingly, the PHI appeared to show more distinction between sites of high and low quality than did the Montgomery County indicator. There were three sites rated as Good by the PHI: MB 10, MB 1, and CS 8. Most sites scored in the Fair and Poor categories, and there were two sites (MB 5 and CS 3) in the Very Poor category.

Table 2-10. City of Gaithersburg, spring qualitative habitat assessment results, Montgomery County protocol

	Site	Instream Cover (0-20)	Epifaunal Substrate (0-20)	Embeddedness (0-20)	Channel Alteration (0-20)	Sediment Deposition (0-20)	Frequency of Riffles (0-20)	Channel Flow Status (0-20)	Bank Veg. Protection Left (0-20)	Bank Veg. Protection Right (0-20)	Bank Stability Left (0-20)	Bank Stability Right (0-20)	Riparian Width Left (0-20)	Riparian Width Right (0-20)	Total Habitat Score (0-200)
Random	MB 1	17	15	14	19	13	15	14	6	3	4	2	9	9	140
	MB 2	16	16	12	10	12	14	13	3	8	8	6	1	10	129
	MB 3	10	7	13	15	14	9	14	5	6	4	5	9	2	113
	MB 5	15	10	8	17	8	13	10	7	5	5	4	9	9	120
	MB 10	14	10	15	15	11	8	13	5	5	5	5	3	9	118
	GST 1	14	5	9	18	7	6	13	7	6	8	5	9	9	116
	GST 2	7	7	14	6	13	11	7	3	5	1	2	3	3	82
	GST 4	15	16	11	15	7	16	8	5	5	6	5	9	2	120
	GST 5	14	12	13	15	8	14	8	3	5	2	3	9	9	115
	GST 8	8	10	9	8	13	11	17	5	5	8	8	1	1	104
	Mean	13	10.8	11.8	13.8	10.6	11.7	11.7	4.9	5.3	5.1	4.5	6.2	6.3	115.7
Targeted	CS 1	16	14	14	12	9	16	10	4	3	4	2	9	9	122
	CS 2	8	6	9	16	6	7	7	5	4	2	3	8	9	90
	CS 3	8	7	8	11	15	2	17	8	5	6	4	4	9	104
	CS 5	14	10	12	19	6	6	6	4	4	6	3	9	9	108
	CS 6	14	10	15	14	9	15	14	3	5	6	4	3	9	121
	CS 7	7	10	18	15	13	19	14	6	6	5	7	9	9	138
	CS 8	15	9	17	10	7	9	9	3	6	7	5	9	9	115

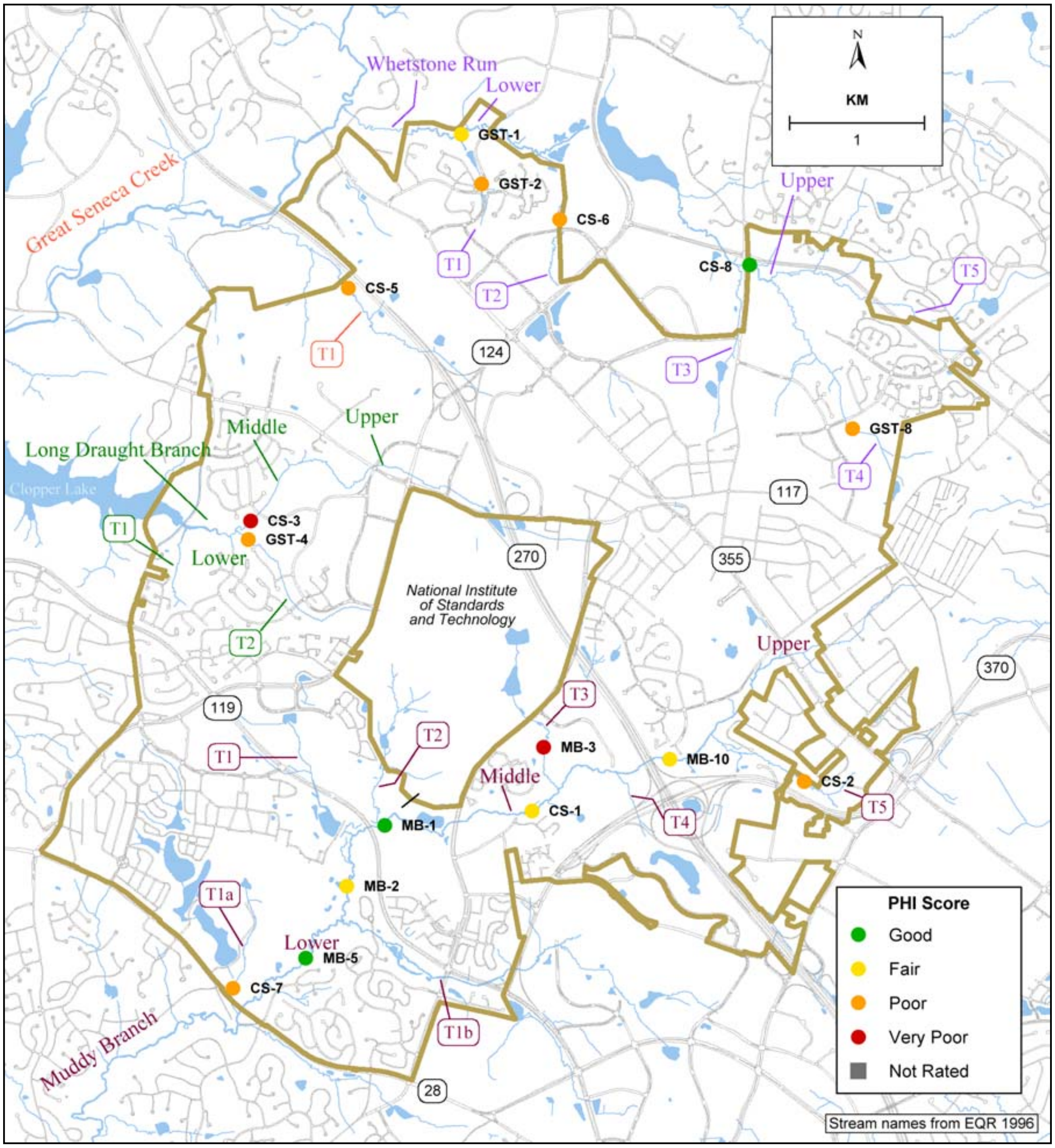


Figure 2-5. Physical Habitat Indicator scores for sites sampled in the City of Gaithersburg, 2001-2002

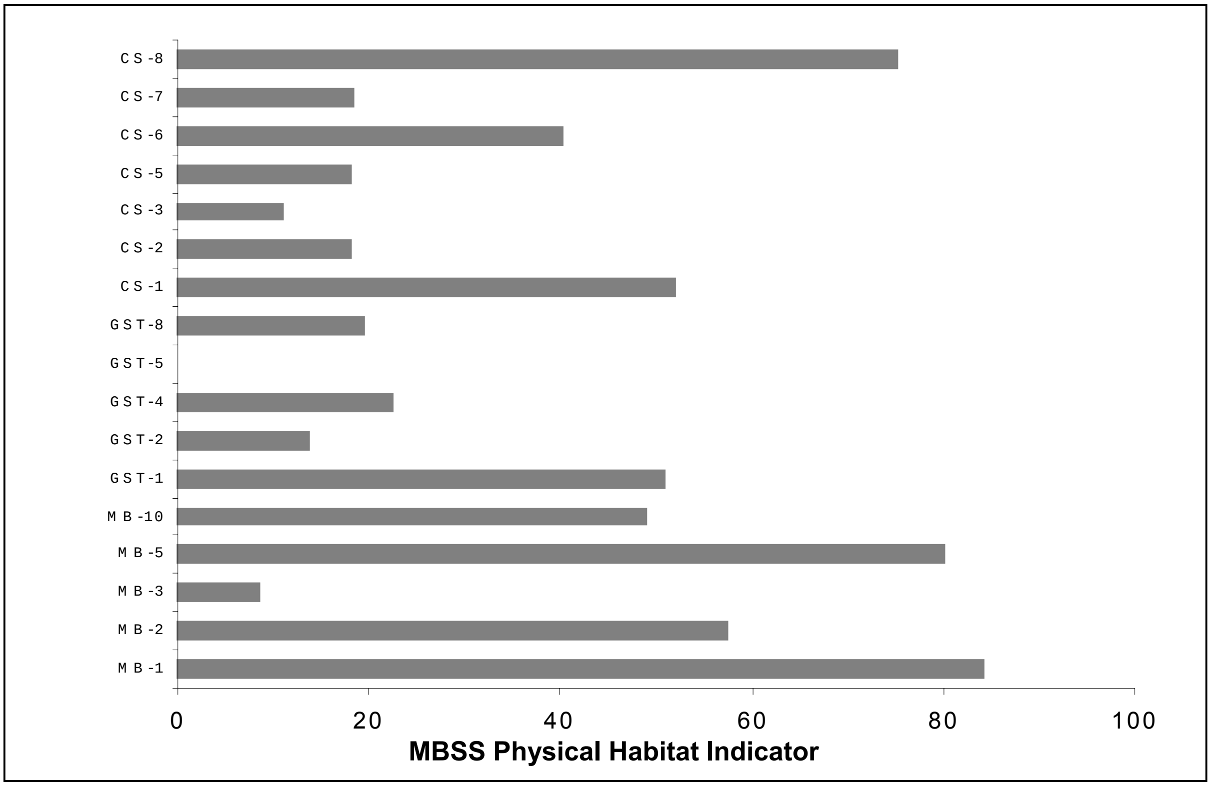


Figure 2-6. MBSS Physical Habitat Indicator for City of Gaithersburg 2001-2002 sampling sites

Table 2-11. City of Gaithersburg, summer qualitative habitat assessment results, MBSS protocol.

	Site	Instream Habitat (0-20)	Epifaunal Substrate (0-20)	Velocity/ Depth Diversity (0-20)	Pool/Glide/ Eddy Quality (0-20)	Riffle/Run Quality (0-20)	Embed-dedness (%)	Shading (%)	PHI (0-100)
Random	MB 1	14	11	13	18	12	35	85	84.2
	MB 2	13	12	12	13	15	20	50	57.5
	MB 3	9	12	6	10	8	35	95	8.5
	MB 5	16	12	15	16	11	15	80	80.0
	MB 10	10	13	10	13	7	25	90	48.8
	GST 1	11	8	13	15	7	35	75	50.9
	GST 2	9	11	7	13	7	25	70	13.6
	GST 4	8	15	7	16	6	45	90	22.5
	GST 8	10	7	8	8	6	30	98	19.5
	Mean	11.1	11.2	10.1	13.6	8.8	29.4	81.4	42.8
Targeted	CS 1	16	10	8	16	10	25	85	51.9
	CS 2	11	12	6	12	6	35	97	17.9
	CS 3	10	13	6	8	6	35	20	11.0
	CS 5	10	10	6	14	7	35	95	17.9
	CS 6	16	15	11	14	11	30	90	40.3
	CS 7	6	9	8	7	10	30	95	18.2
	CS 8	15	16	13	13	14	25	90	75.0

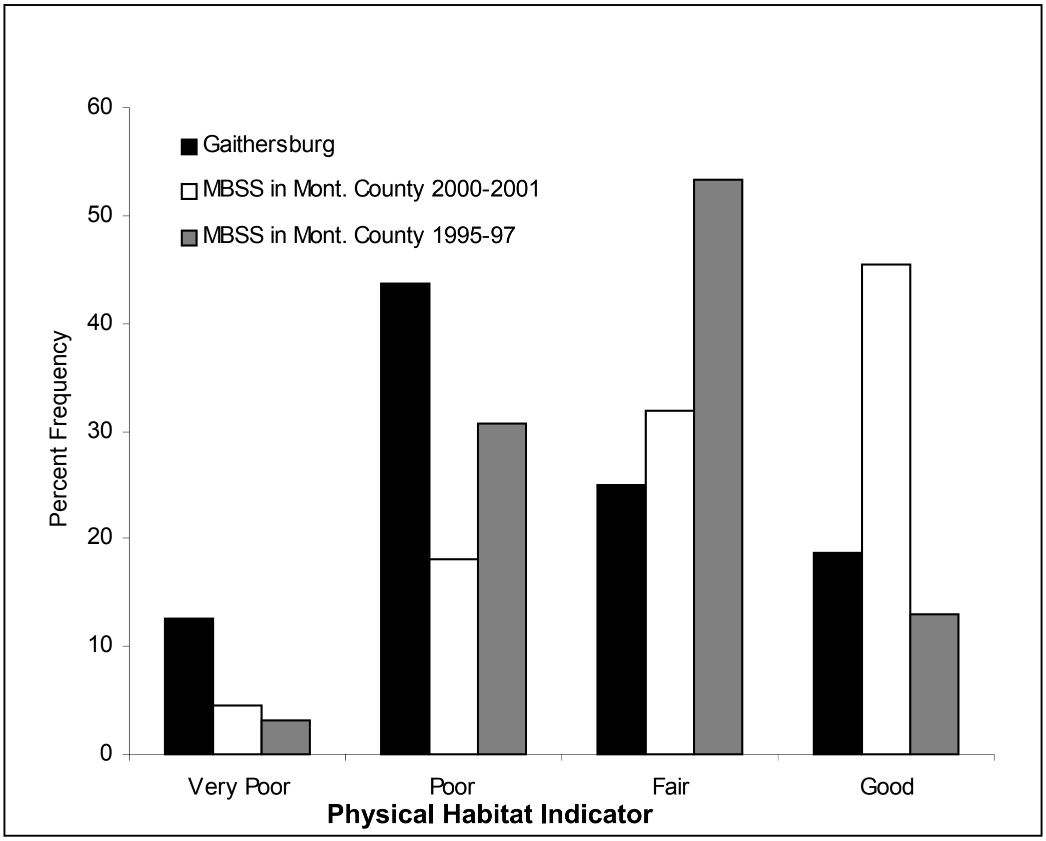


Figure 2-7. Comparison of Gaithersburg Physical Habitat Indicator (PHI) results with MBSS sites in Montgomery County

There are several factors that influence PHI scores, but one of the most important is instream habitat structure. Sites rated as Good generally had lots of habitat available for fish, including large rocks, deep pools, undercut banks, and woody debris. Sometimes these forms of habitat come from man-made sources. For instance, site CS 8 scored high for instream habitat because riprap placed to support stream banks had fallen into the stream channel, which provided significant fish habitat.

The PHI provides a means of comparing Gaithersburg streams with those sampled elsewhere. MBSS Round One (1995-1997) collected information at sites throughout Montgomery County. More recently, MBSS Round Two has collected data within Montgomery County in Brighton Dam and Seneca Creek watersheds during 2000-2001; remaining parts of the County will be sampled by 2004. A comparison of Gaithersburg data with these MBSS data sets (Figure 2-7) shows that PHI scores for Gaithersburg sites fell within the same broad range, from Good to Very Poor, but the City had an greater percentage of sites in the Poor range, while the two MBSS groups had a majority of Fair to Good.

Because the MBSS sites represent a broad spectrum of both urban and non-urban catchments, a second comparison was made, this time using only those MBSS sites in Montgomery County with a substantial amount of urban land (those having catchment area more than 25%

urban). Figure 2-8 compares the PHI scores of Gaithersburg streams to those of streams in Montgomery County sampled by the MBSS with greater than 25% urban land use. Results for 1997-2001 were grouped because of the small number of sites (n=16). Results indicate that Gaithersburg streams scored, on average, slightly lower than similar streams in the County.

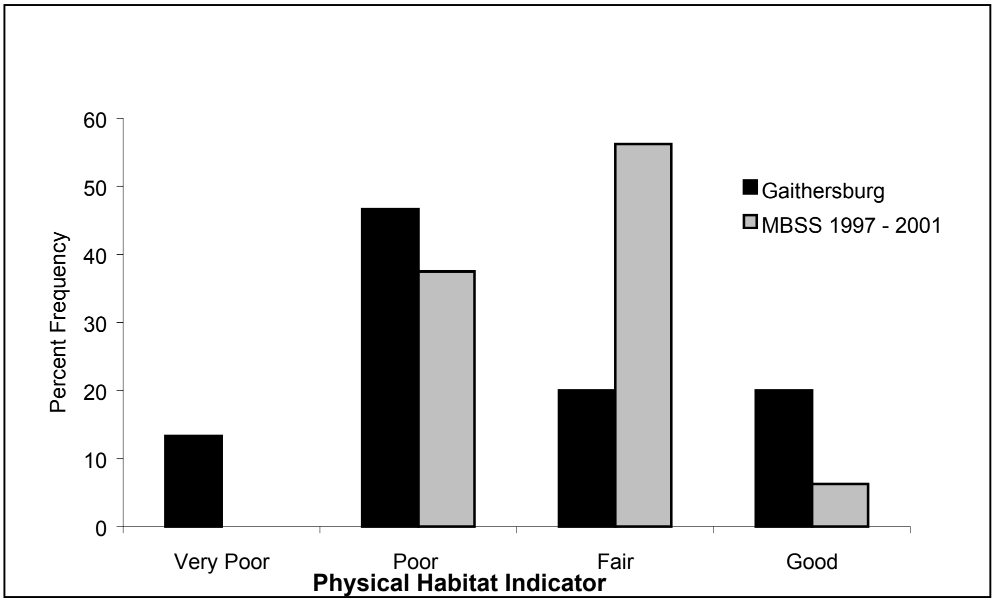


Figure 2-8. Comparison of Gaithersburg Physical Habitat Indicator (PHI) results with MBSS sites in Montgomery County, MBSS urban sites only

2.2.2.2 Riparian Buffers

A complete characterization of stream habitat goes beyond in-channel measures and includes the area adjacent to the stream, termed the riparian zone. Riparian buffer vegetation plays an important role in protecting stream habitat and water quality. Streamside trees and other vegetation can filter nutrients, sediments, and other pollutants, preventing them from entering streams. Vegetation also provides bank stabilization, shade, overhead cover, leaf litter to feed the aquatic food web, and large woody debris habitat.

This stream assessment described the extent of riparian vegetation at each sampled site, estimated as the functional width of the riparian. In the field, buffer width is estimated for up to 50 m on each side of the stream. Results (Figure 2-9) show that many sampled sites had fairly extensive buffers. Twelve of 17 sites had a 50 m buffer on at least one side, and six sites had 50 m of vegetation on both sides of the stream. A few sites (e.g., GST 8) had very little vegetation.

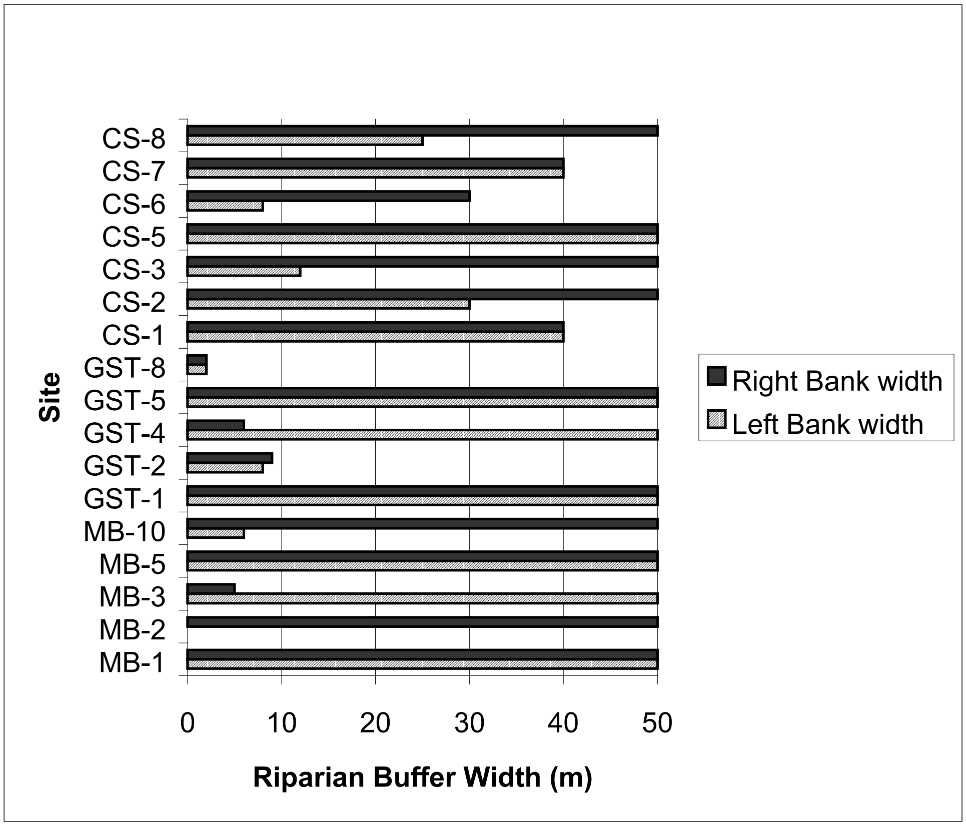


Figure 2-9. Riparian buffer width (to 50 meters) for City of Gaithersburg 2001-2002 sampling sites

2.2.2.3 Bank and Channel Stability

Bank erosion is a substantial and widespread problem in Gaithersburg streams. Figure 2-10 summarizes field ratings of the degree of bank erosion observed, based on the MBSS sampling method. All sites exhibited some degree of bank erosion, whether minimal, moderate, or severe. Moderate to severe bank erosion was observed at 15 of 16 sites. Bank erosion was rated as severe at five sites (along at least one side of stream), and severe erosion was noted along both banks at GST-2.

Bank pins were installed and monitored during each sampling period to aid in quantifying bank erosion rates. Only a few changes were recorded over the seven-month interval between bank pin installation (December 2001) and final sampling (June 2002). All changes were at Great Seneca Tributary sites. Site GST 2 lost 4 cm of bank between spring and summer. Site CS 5 lost 2cm by between fall and spring, and an additional 2 cm by summer. At site GST 8, the bank slumped between spring and summer (showing an apparent gain of 8 cm at the bank pin location. Because bank pin assessments are a good long-term assessment tool, all bank pins were left in place at the conclusion of summer field sampling. We recommend periodic monitoring of these pins in future years to further evaluate bank erosion.

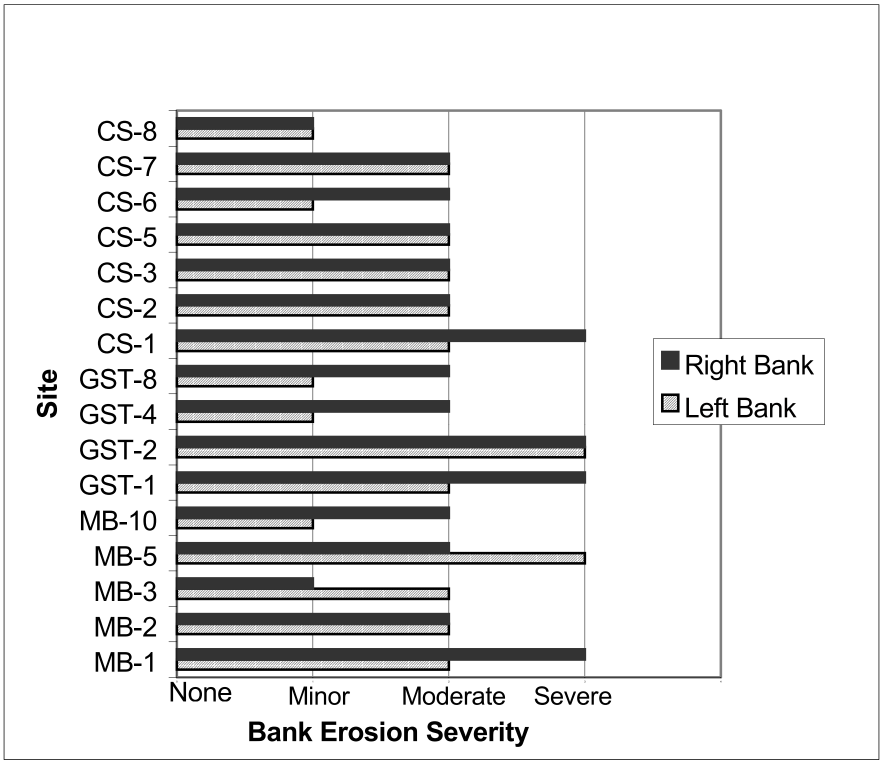


Figure 2-10. Bank erosion observed at City of Gaithersburg 2001-2002 sampling sites

Formation of side or mid-channel bars is another sign of channel instability. Unstable channels, in which gravel and sand substrate shift readily with high flows, are common in much of the stream network in Gaithersburg. Channels that are already entrenched because of prior downcutting and incision are particularly vulnerable to further instabilities of channel and bank materials because they no longer support a natural hydrologic and sediment transport regime.

All sites showed some extent of bar formation (Figure 2-11). Assessments, using MBSS protocols, rate bar formation as minor, moderate, and extensive. Bar formation was moderate to extensive at 12 of 16 sites. Gravel and sand were the predominant bar materials noted.

Historic or recent channelization can contribute to channel instability by altering the natural stream channel morphology and flow regime. When naturally meandering channels are straightened or confined, flows can be concentrated, velocities increased, and erosion made worse. Evidence of channelization was observed at ten sites.

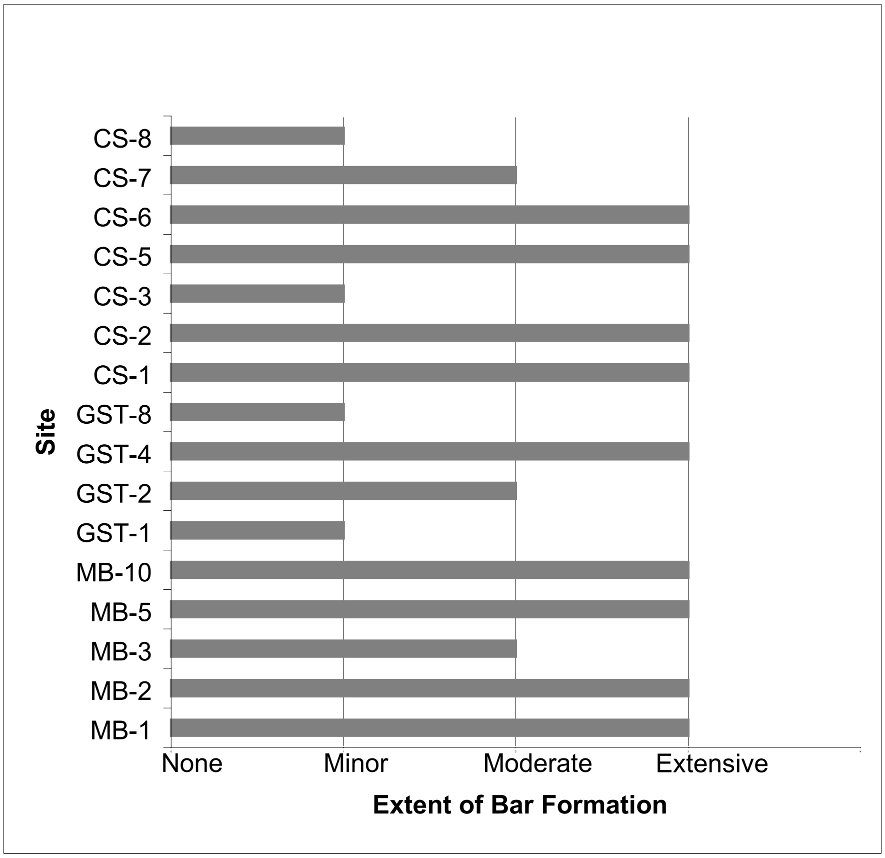


Figure 2-11. Extent of bar formation at City of Gaithersburg 2001-2002 sampling sites

2.2.2.4 Cross-Sectional Profiles

Cross-sectional profiles were surveyed at each site in the fall as part of the stream geomorphic assessment. Cross section endpoints were marked with permanent stakes and relative benchmarks were established so that it will be possible to return to the sites in the future and re-survey the same cross-section to detect physical changes to the bank and channel morphology.

Two examples of cross-sectional data from GST 8 and CS 5 are shown in Figures 2-12 and 2-13. GST 8 represents a more natural channel condition, with a wetted channel that fills the stream channel from bank to bank. This site has gradually sloping banks, indicating minimal sediment deposition, bank erosion, and relatively stable flows. In contrast, the cross section for CS 5 shows that the stream channel is overwidened and has high, steep banks. A relatively small amount of flow is present within a much larger channel, with a substantial sediment bar filling much of the channel width. This is likely a result of flashy flows, severe bank erosion, high sediment loads, and excessive sediment deposition. A complete set of graphs for cross-sections

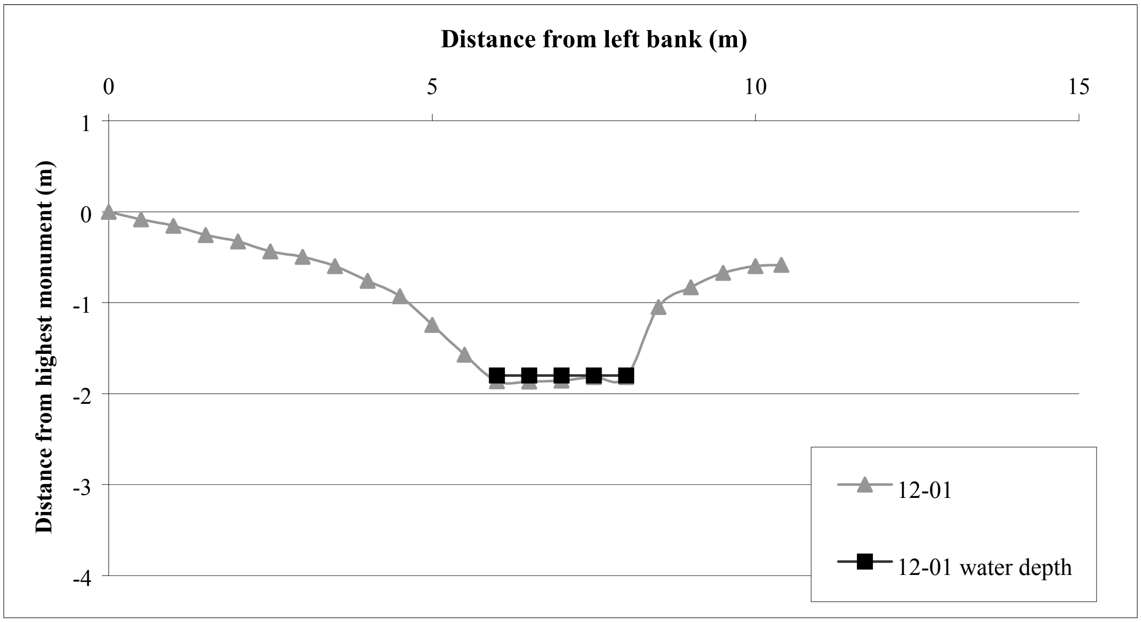


Figure 2-12. Cross-sectional profile of station GST 8, City of Gaithersburg 2001-2002 sampling

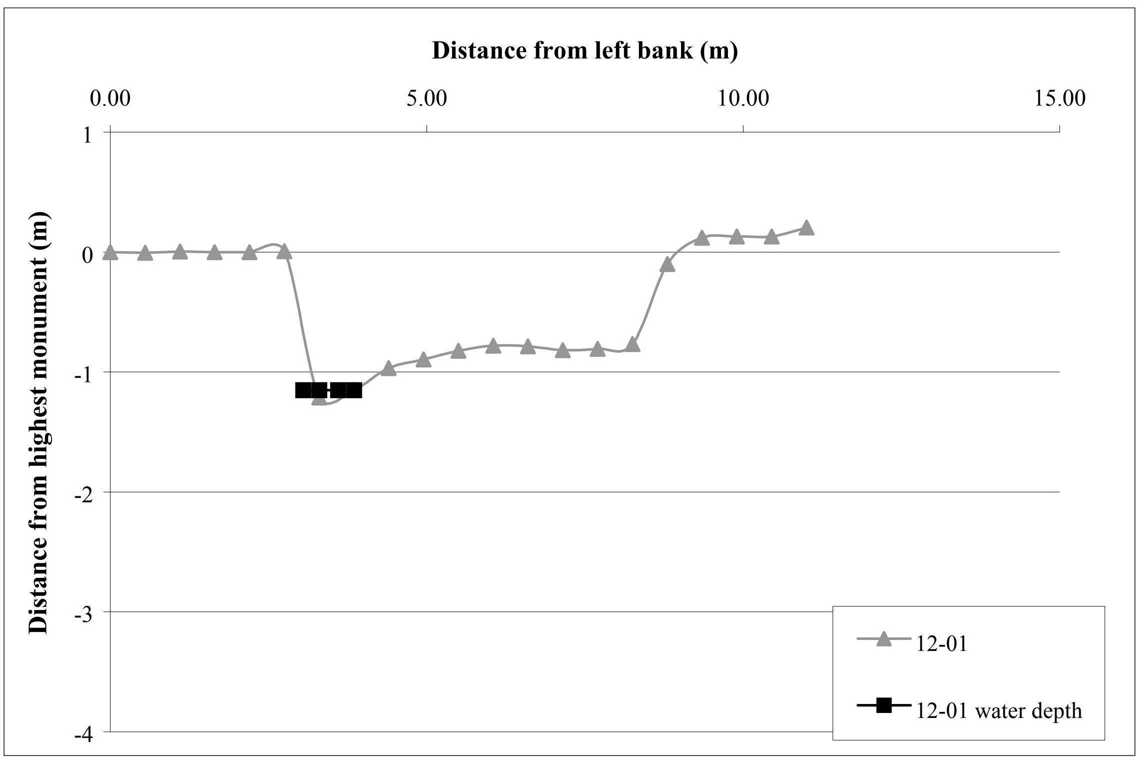


Figure 2-13. Cross-sectional profile of station CS 5, City of Gaithersburg 2001-2002 sampling

at each site are included in Appendix B. In general, cross-sections of the Gaithersburg stream sites confirmed other observations that channels are highly impacted, with a high degree of channel incision, mild to severe bank erosion, and extensive bar formation.

2.2.2.5 Longitudinal and Cross-sectional Habitat Profiles

Habitat units along the length of each 75-meter segment were measured to create a descriptive longitudinal profile based on habitat type. Pools, riffles, and runs were measured in sequence, starting from the downstream end, and recorded to the nearest meter. Table 2-12 shows the percentage of pool, riffle, and run habitat at each site, along with an average of the nine randomly selected sites. These data serve simply as a general characterization of the habitat types found at each site.

Cross-sectional measures were taken at 25-m intervals (i.e., at 0-, 25-, 50-. and 75-m marks along the stream segment). These individual measurements were averaged by site, as shown in Table 2-12. Note that the “Average canopy cover” values shown here are based on the average of four single observations at the 0, 25, 50, and 75 meter marks. MBSS percentages for shading (Table 2-13) are based on a visual estimate of average stream shade, based on expected shade throughout the day, and thus tended to be higher.

Table 2-12. City of Gaithersburg fall habitat results - transect parameters

Site Type	Site	Average Wetted Width (m)	Average Channel Width (m)	Average Thalweg Depth (m)	Average Canopy Cover (%)	Average Percent Vegetated, Left Bank (%)	Average Percent Vegetated, Right Bank (%)
Random	MB 1	4.5	9.6	0.4	47.5	82.5	57.5
	MB 2	5.9	7.9	0.4	40.0	47.5	55.0
	MB 3	2.9	4.5	0.2	80.0	47.5	45.0
	MB 5	6.3	9.5	0.4	37.5	42.5	60.0
	MB 10	4.7	6.4	0.4	77.5	25.0	12.5
	GST 1	3.8	7.6	0.3	10.0	70.0	72.5
	GST 2	1.6	5.4	0.2	12.5	57.5	70.0
	GST 4	3.4	9.9	0.2	60.0	32.5	27.5
	GST 8	1.7	3.9	0.1	47.5	70.0	62.5
	Mean*	3.9	7.2	0.3	45.8	52.8	51.4
Targeted	CS 1	7.4	9.0	0.6	55.0	37.5	35.0
	CS 2	2.5	5.5	0.2	67.5	7.5	5.0
	CS 3	3.3	5.6	0.1	5.0	87.5	57.5
	CS 5	2.3	6.9	0.2	42.5	16.3	10.0
	CS 6	2.8	4.4	0.3	62.5	35.0	15.0
	CS 7	2.2	4.0	0.2	88.8	65.0	67.5
	CS 8	2.9	7.0	0.3	45.0	30.0	20.0

* Mean value for all randomly selected site; represents the estimated average condition for all streams Citywide.

Table 2-13. Percentage of stream habitat types found within City of Gaithersburg stream monitoring sites

Site Type	Site	Percent Pool	Percent Riffle	Percent Run
Random	MB1	58.7%	41.3%	0.0%
	MB2	48.0%	29.3%	22.7%
	MB3	49.3%	26.7%	24.0%
	MB5	73.3%	26.7%	0.0%
	MB10	29.3%	32.0%	38.7%
	GST1	70.7%	29.3%	0.0%
	GST2	17.3%	36.0%	46.7%
	GST4	38.7%	57.3%	4.0%
	GST8	25.3%	38.7%	36.0%
	Mean *	45.6%	35.3%	19.1%
Targeted	CS1	62.7%	33.3%	4.0%
	CS2	56.0%	18.7%	25.3%
	CS3	0.0%	12.0%	88.0%
	CS5	52.0%	24.0%	24.0%
	CS6	29.3%	58.7%	12.0%
	CS7	5.3%	72.0%	22.7%
	CS8	25.3%	29.3%	45.3%

* Mean value for all randomly selected site; represents the estimated average condition for all streams Citywide.

2.2.2.6 Stream Flow and Gradient

Stream discharge (flow), measured in cubic feet per second (cfs), and stream slope (gradient) were computed from cross-sectional and longitudinal survey data collected at each site in both the fall and the summer. Results are shown in Tables 2-14 and 2-15. Table 2-14 shows discharges at each site during the fall and summer sampling seasons. Drought conditions during summer 2002 resulted in very low flows in the City's streams; a rainstorm during one of the summer sampling days gives MB 2 and MB 5 the appearance of having much larger discharges than the rest of the sites. Although these data represent snapshots of flow conditions at particular points in time, a more complete picture of streamflow patterns would require data from a continuous-recording flow recorder at one or more sites of interest.

Table 2-15 shows discharge levels at each site as they appear in order along the stream, to show the increase in flow with downstream position in the watershed, as tributaries and ground-water enter the mainstem. Discharge values for Muddy Branch and Great Seneca tributary appear as anticipated, with discharge values increasing with distance downstream. The only exception is the fall measurement at MB5, which shows a lower discharge than upstream sites. Unfortunately this pattern could not be verified by comparison to summer measurements at MB5 because of rain during summer sampling.

Table 2-14. Stream discharges and slope

		Fall sampling		Summer sampling	
	Site	**Discharge (cfs)**	**Slope**	**Discharge (cfs)**	**Comments**
Random	MB-1	0.063	0.0076	0.948	
	MB-2	0.093	0.0097	3.897	rained earlier in day
	MB-3	0.061	0.0097	0.184	
	MB-5	0.056	0.0037	9.611	rained while sampling
	MB-10	0.004	0.0063	0.237	
	GST-1	0.105	0.0038	2.552	
	GST-2	0.007	0.0120	0.219	
	GST-4	0.002	0.0146	0.097	
	GST-8	0.004	0.0124	0.788	
	Mean*	0.044	0.0089	2.059	
Targeted	CS-1	0.058	0.0057	0.924	
	CS-2	0.002	0.0123	0.063	
	CS-3	0.013	0.0017	0.254	
	CS-5	0.002	0.0056	0.187	
	CS-6	0.137	0.0155	0.400	
	CS-7	**	0.0094	1.482	
	CS-8	**	0.0029	1.533	

* Mean value for all randomly selected site; represents the estimated average condition for all streams Citywide.
** Not measured; sites were added in Spring 2002.

Table 2-15. Stream discharge, ordered by relative position along stream (from upstream to downstream).

	Position on Stream Reach	**Site**	**Fall Discharge (cfs)**	**Summer Discharge (cfs)**
Muddy Branch	1st	CS 2	0.002	0.063
	2nd	MB 10	0.004	0.237
	3rd	CS 1	0.058	0.924
	4th	MB 1	0.063	0.948
	5th	MB 2	0.093	3.897
	6th	MB 5	0.056	9.611
Great Seneca Tributary	1st	GST8	0.004	0.788
	2nd	CS8	not available	1.533
	3rd	GST1	0.105	2.552

2.2.2.7 Stream Substrate

Pebble counts quantitatively characterize stream substrate. The representative median particle size of channel bottom and bank is calculated by measuring the intermediate axis of 100 systematically sampled particles. A higher D50 measurement indicates that the substrate in the stream was relatively large, such as small and large cobble, while a small D50 indicates smaller substrate is present, such as sand and silt. D50 values from the 16 Gaithersburg sites are shown in Figure 2-14, which indicates that most streambeds are made up of medium sized gravel, except for MB 5, GST 8, CS 3, and CS 8, which were predominantly sand bottoms.

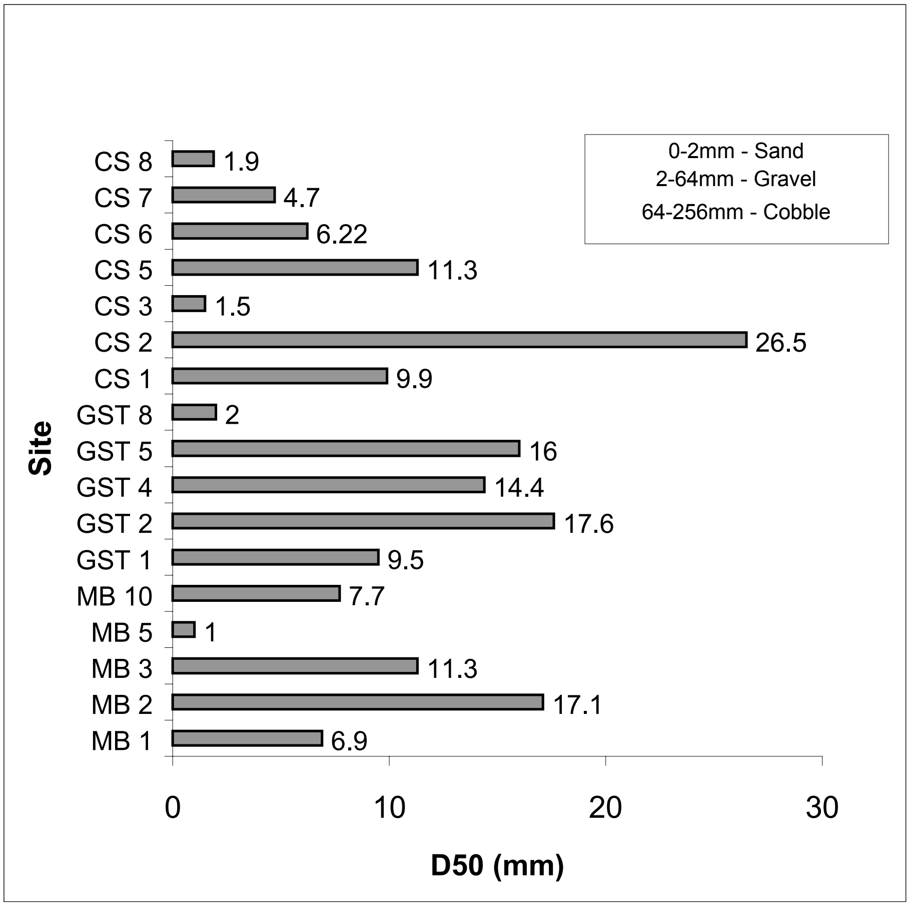


Figure 2-14. Median substrate particle size (D50) for City of Gaithersburg 2001-2002 sampling sites

Average substrate size is dependent on geographic location and gradient. For example, Highland streams are expected to have larger substrate such as boulders and large cobble, while Coastal Plain streams are expected to have smaller substrate such as sand. In the Piedmont, expected substrate size could vary greatly under natural conditions, but would generally fall between large gravel and cobble. Within a geographic area, high gradient streams would tend to have larger substrate, as smaller particles are more easily moved downstream by swifter flow velocities resulting from steeper channel slopes. Smaller substrate, such as silt and sand, are often evidence of high sediment load and its transport within the stream channel. This sediment load settles in the interstitial spaces between larger substrate, filling in valuable benthic habitat (i.e., resulting in high embeddedness).

2.2.3 Water Quality

Results for water quality parameters measured in the City's streams suggested some water quality problems typical of urban streams. Results from the three sampling seasons are shown in Tables 2-16 through 2-18. Bar charts in Figures 2-15 through 2-19 show the individual results recorded at each site, compared seasonally.

Fall data showed that water temperatures were about normal for the time of year (5 to 11EC), as were dissolved oxygen values (9 to 13 mg/L) (Table 2-16). Turbidity was also normal. However, turbidity is best assessed under a range of baseflow and storm event conditions; these values represent only a single baseflow measurement and are not a good predictor of overall turbidity problems that may occur.

Table 2-16. Water chemistry results from fall sampling, City of Gaithersburg stream assessment

	Site	Water Temperature (^oC)	Dissolved Oxygen (mg/L)	pH	Conductivity (Fmho/cm)	Turbidity (NTU)
Random	MB 1	9.89	12.31	5.88	310	4.4
	MB 2	7.07	13.10	6.26	227	4.4
	MB 3	8.20	12.60	7.78	618	5.5
	MB 5	7.76	13.60	6.58	328	4.7
	MB 10	8.53	13.50	8.09	648	0.6
	GST 1	9.79	12.55	7.95	410	9.3
	GST 2	11.05	10.50	7.81	394	1.8
	GST 4	7.01	12.31	7.36	315	3.1
	GST 5	8.16	12.65	6.72	257	11.3
	GST 8	8.61	11.60	6.04	315	4.1
	Mean*	8.61	12.47	7.05	382	4.9
Targeted	CS 1	8.37	13.60	7.95	678	2.3
	CS 2	10.18	9.10	5.70	296	4.4
	CS 3	7.58	12.30	7.31	595	2.9
	CS 5	5.03	11.62	6.69	665	4.7
	CS 6	10.02	10.78	5.51	280	3.2

* Mean value for all randomly selected sites; represents the estimated average condition for all streams Citywide.

At several sites (MB 1, CS 2, and CS 6) the pH was below 6.0, which is considered a crucial threshold at which many aquatic species become stressed or cannot survive. The Code of Maryland Regulations (COMAR) water quality standards for minimum pH values in Maryland streams is 6.5. The occurrence of low pH streams is notable, given that streams of Central Maryland are generally well-buffered from the impacts of acid rain that are common elsewhere in the state. Low pH can be an indicator of pollutant inputs.

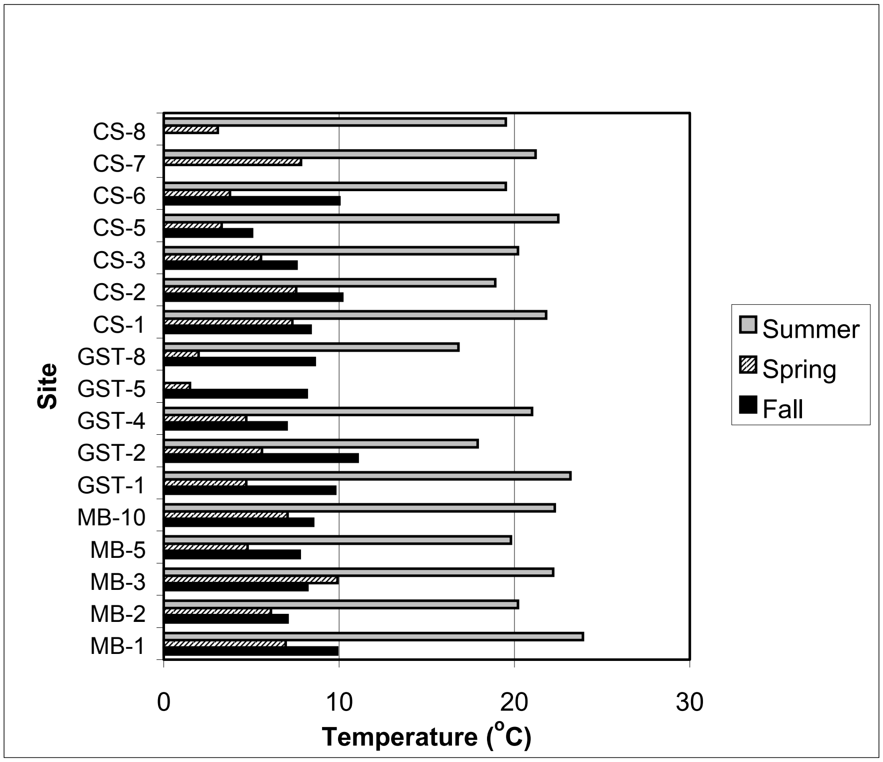


Figure 2-15. Water temperature (°C) at City of Gaithersburg 2001-2002 sampling sites

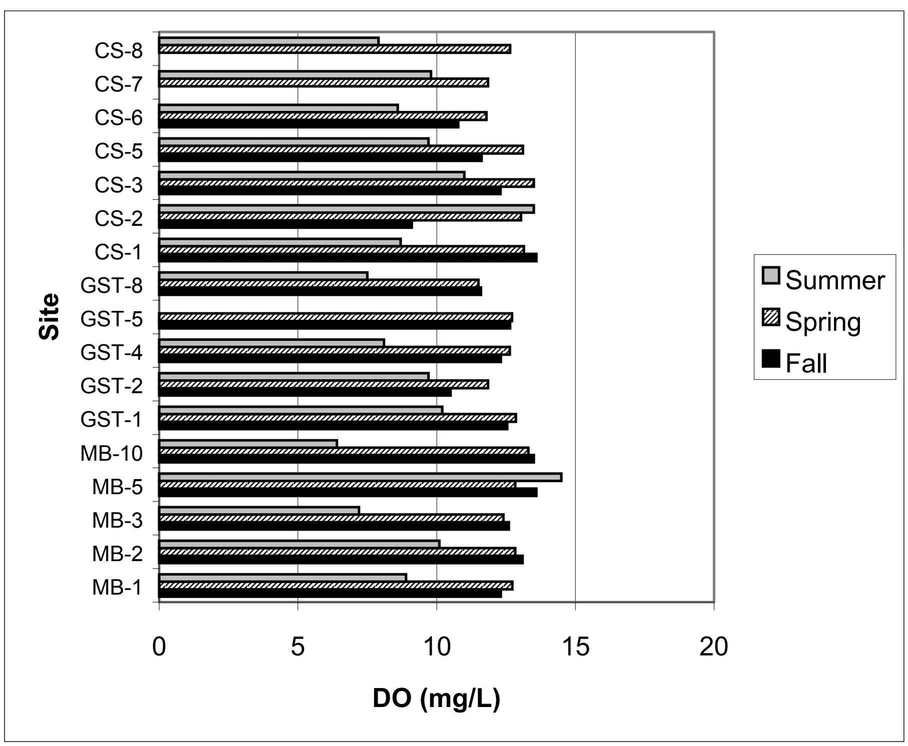


Figure 2-16. Dissolved Oxygen (mg/L) at City of Gaithersburg 2001-2002 sampling sites

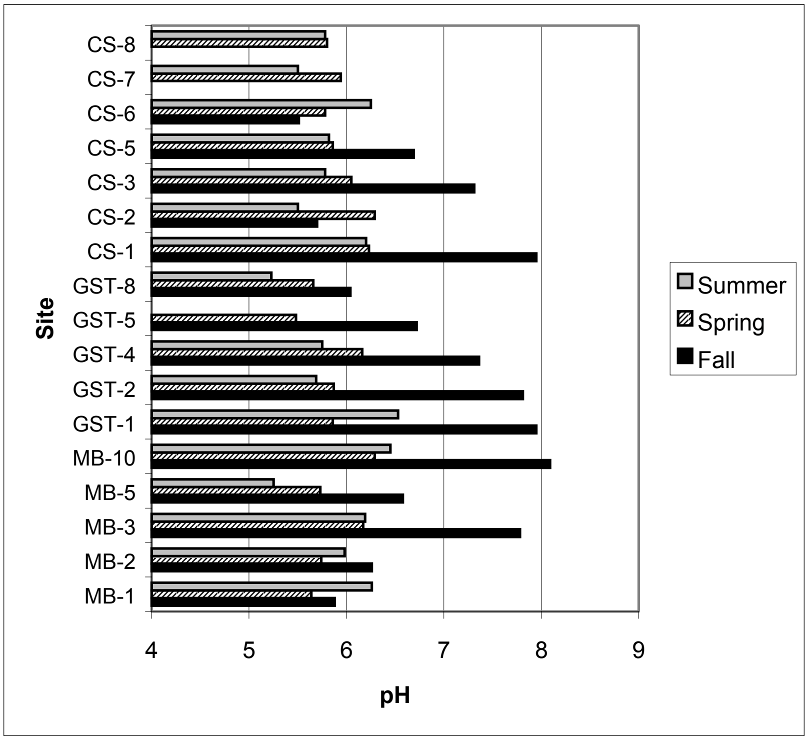


Figure 2-17. pH (standard units) at City of Gaithersburg 2001-2002 sampling sites

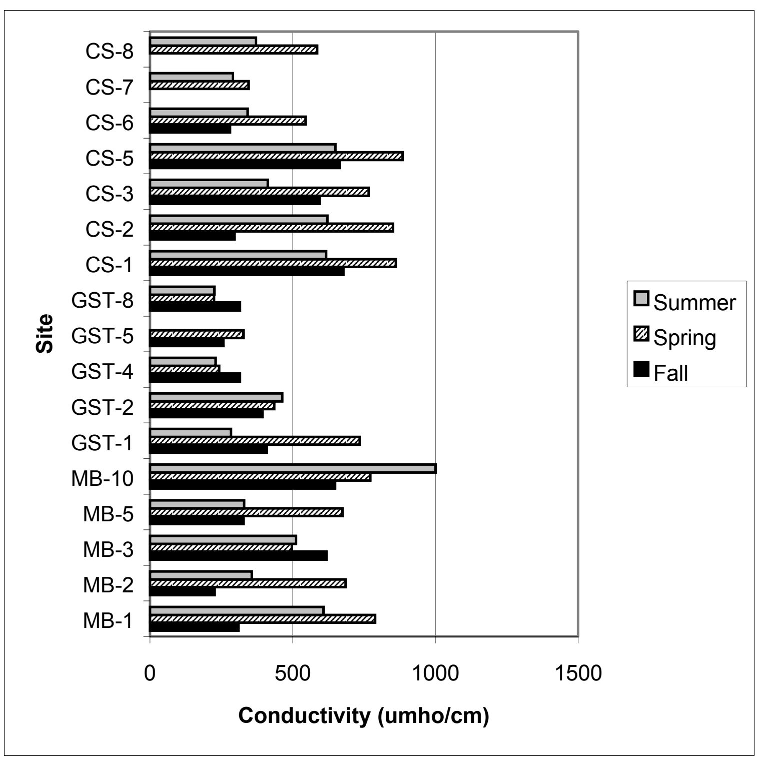


Figure 2-18. Conductivity (μmho/cm) at City of Gaithersburg 2001-2002 sampling sites

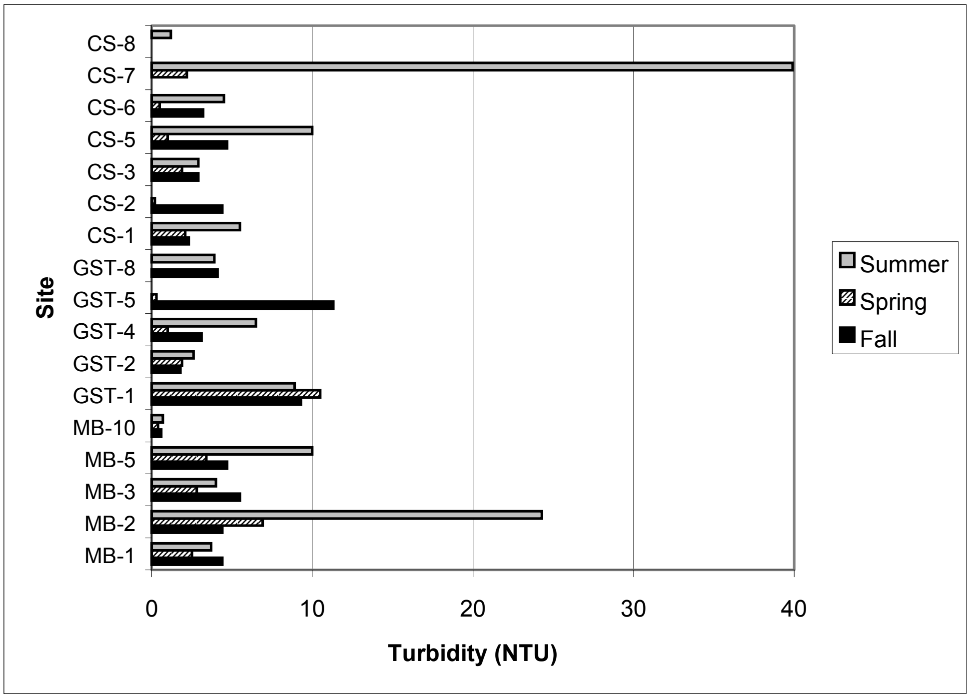


Figure 2-19. Turbidity (NTUs) at City of Gaithersburg 2001-2002 sampling sites

In addition, conductivity was somewhat high at several sites, including MB 3, MB 10, CS 1, and CS 5. While conductivity may be related to dissolved minerals stemming from underlying geology, in some cases, unusually high or variable conductivity can indicate pollution.

In the spring, water temperature, dissolved oxygen (DO), and turbidity were again within a normal range, with few changes other than those associated with cooler weather, as seen in the lower water temperatures (Table 2-17). However, pH values were more extreme, with all 16 observations below pH 6.5, and 11 of those had a pH less than 6.0. Spring conductivity values were somewhat higher than the previous fall. Runoff of road salts from winter de-icing may have contributed, but other pollutant sources are also possible. Conductivity values at every site but one (GST 8) were higher than those measured in the fall, suggesting that anthropogenic influences, not natural geologic conditions, are the cause of the high conductivity values.

Summer water quality is presented in Table 2-18. In general, conductivity measurements were lower than those observed in the spring, with the exception of MB 10, where conductivity was alarmingly high (1001 Fmho/cm). Water temperatures in the summer were warm, which is to be expected since it was an extremely hot period in late June 2002. DO values were lower in the summer, as expected, since DO levels tend to fall with rising water temperatures. However, all sites remained above 5 mg/L DO, the COMAR standard and the level generally considered healthy for aquatic life.

Table 2-17. Water chemistry results from spring sampling, City of Gaithersburg stream assessment

	Site	Water Temperature (^oC)	Dissolved Oxygen (mg/L)	pH	Conductivity (Fmho/cm)	Turbidity (NTU)
Random	MB 1	6.95	12.73	5.64	789	2.5
	MB 2	6.12	12.83	5.74	685	6.9
	MB 3	9.91	12.41	6.17	497	2.8
	MB 5	4.79	12.83	5.73	674	3.4
	MB 10	7.06	13.31	6.29	772	0.4
	GST 1	4.70	12.86	5.86	735	10.5
	GST 2	5.60	11.85	5.87	435	1.9
	GST 4	4.71	12.64	6.16	242	1.0
	GST 5	1.50	12.72	5.48	328	0.3
	GST 8	1.99	11.51	5.66	224	0
	Mean*	5.33	12.57	5.86	538	3.0
Targeted	CS 1	7.34	13.15	6.23	862	2.1
	CS 2	7.55	13.04	6.29	852	0.2
	CS 3	5.54	13.5	6.05	766	1.9
	CS 5	3.31	13.11	5.86	885	1.0
	CS 6	3.78	11.79	5.78	545	0.5
	CS 7	7.82	11.85	5.94	345	2.2
	CS 8	3.09	12.65	5.80	586	0

* Mean value for all randomly selected sites; represents the estimated average condition for all streams Citywide.

Table 2-18. Water chemistry results from summer sampling, City of Gaithersburg stream assessment

	Site	Water Temperature (^oC)	Dissolved Oxygen (mg/L)	pH	Conductivity (Fmho/cm)	Turbidity (NTU)
Random	MB 1	23.9	8.9	6.26	608	3.7
	MB 2	20.2	10.1	5.98	357	24.3
	MB 3	22.2	7.2	6.19	512	4
	MB 5	19.8	14.5	5.25	330	10.0
	MB 10	22.3	6.4	6.45	1001	0.7
	GST 1	23.2	10.2	6.53	284	8.9
	GST 2	17.9	9.7	5.69	463	2.6
	GST 4	21.0	8.1	5.75	230	6.5
	GST 8	16.8	7.5	5.23	226	3.9
	Mean*	20.8	9.2	5.93	446	7.2
Targeted	CS 1	21.8	8.7	6.20	617	5.5
	CS 2	18.9	13.5	5.50	622	0
	CS 3	20.2	11.0	5.78	413	2.9
	CS 5	22.5	9.7	5.82	650	10.0
	CS 6	19.5	8.6	6.25	342	4.5
	CS 7	21.2	9.8	5.50	291	39.9
	CS 8	19.5	7.9	5.78	371	1.2

* Mean value for all randomly selected sites; represents the estimated average condition for all streams Citywide.

Summer pH levels remained similar to those recorded in the spring, with 10 sites having a pH less than 6.0. To assess whether pH values for Gaithersburg streams differed from those elsewhere in the region, data were compared with MBSS sites sampled throughout Montgomery County. In comparison, summer pH values in Gaithersburg tended to be lower than elsewhere in the County (Figure 2-20).

Turbidity was normal at most sites, but there were two sites that exhibited somewhat higher measurements. MB 2 (turbidity of 24.3 NTU) was sampled just as a slight rainstorm was beginning to break. Rainwater carries fine particles into the stream, which raises turbidity levels. CS 7 also had high turbidity (39.9 NTU), but was sampled during dry conditions. CS 7 is located just below a confluence of two smaller tributaries; one is the outfall of pond by the GE complex, and the other runs by the new Lakelands development. The water from the pond outfall was clear, while the water from the active development area was quite turbid. This was believed to be the source of the high turbidity level observed at this site.

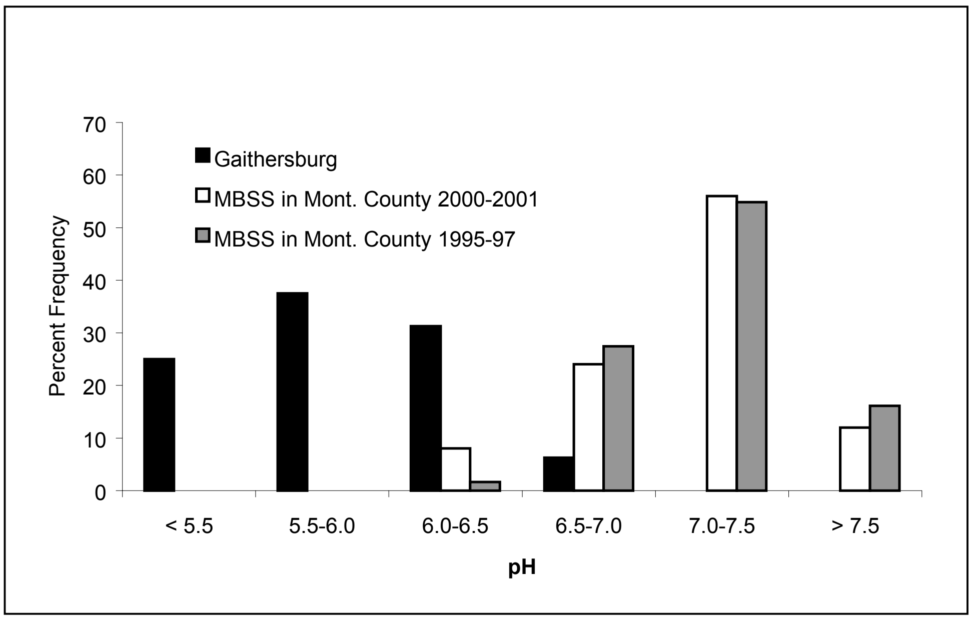


Figure 2-20. Comparison of Gaithersburg Summer pH Results with MBSS Sites in Montgomery County

2.2.4 Benthic Macroinvertebrates

At the 17 Gaithersburg stream sites sampled for benthic macroinvertebrates in spring 2002, 93 taxa were found (see Appendix C for a complete list of these taxa). Table 2-19 lists the top 10 most abundant taxa found in the samples.

Table 2-19. Top 10 most abundant benthic macroinvertebrate taxa found in the City of Gaithersburg stream samples, spring 2002

Scientific Name	Common Name	Total Abundance
Meropelopia	Midge	164
Nais	Worm	150
Cricotopus	Midge	109
Thienemanniella	Midge	90
Cheumatopsyche	Caddisfly	89
Crangonyx	Amphipod	72
Immature tubificid w/o hair chaetae	Worm	54
Tanytarsus	Midge	52
Conchapelopia	Midge	49
Hydropsyche	Caddisfly	47

These 10 taxa account for approximately 56% of the total number of individuals counted. Seven of the 10 most abundant taxa were either midges or worms, taxa known to be among some of the most pollution-tolerant benthic organisms. Although caddisflies (Trichoptera) as a whole tend to be more pollution sensitive, the two genera listed here (Cheumatopsyche and Hydropsyche) are known to be moderately tolerant of pollution.

Several individual descriptors of the benthic community were examined as indicators of stream condition. Table 2-20 includes these metrics, as well as the final benthic IBI score.

Table 2-20. Individual benthic metric values and final benthic IBI score for sites sampled in the City of Gaithersburg, spring 2002.

	Site	Total Number of Taxa	Number of EPT Taxa	Number of Intolerant Taxa	Benthic IBI
Random	MB-1	32	3	0	2.56
	MB-2	25	3	0	2.56
	MB-3	19	2	0	1.89
	MB-5	21	1	0	2.78
	MB-10	17	3	1	2.11
	GST-1	24	2	0	2.78
	GST-2	21	2	0	1.44
	GST-4	18	2	1	2.11
	GST-5	24	2	1	2.78
	GST-8	33	0	1	2.78
	Mean*	23	2	0.4	2.38

Table 2-20 (Continued)					
	Site	**Total Number of Taxa**	**Number of EPT Taxa**	**Number of Intolerant Taxa**	**Benthic IBI**
Targeted	CS-1	25	2	0	2.56
	CS-2	10	0	0	1.44
	CS-3	21	0	0	2.11
	CS-5	19	1	0	2.11
	CS-6	16	2	0	2.11
	CS-7	24	5	3	3.44
	CS-8	28	3	1	2.78
* Mean value for all randomly selected sites; represents the estimated average condition for all streams Citywide.					

The total number of taxa collected at each site was fairly high, with values ranging from 10 at site CS 7 to 33 at site GST 8, indicating a relatively diverse biological community. The number of EPT (Ephemeroptera, Plecoptera, and Trichoptera) taxa per site was low, ranging from zero to five, indicating that most of the taxa found at Gaithersburg sample sites were more tolerant taxa such as midges and worms. The values for the number of intolerant taxa metric also support this conclusion. Most sites (11 of 17, or 65%) had no taxa intolerant to disturbance. Only 1 site had more than one intolerant benthic taxon, site CS 7, which had 3 intolerant taxa.

Final benthic IBI scores ranged from 1.44 (Very Poor) to 3.44 (Fair). The geographic distribution of these scores is shown in Figure 2-21. The mean benthic IBI score at the 10 randomly selected sites was 2.38, indicating the Gaithersburg streams were generally in Poor condition. In comparison with MBSS Round One data, this value was slightly lower than the statewide mean benthic IBI of 2.79 (Poor) and the mean benthic IBI for sites within Montgomery County of 2.83 (Poor).

Interestingly, although a number of MBSS sites in the County scored in the Good to Fair range, indicating conditions comparable to reference, only one Gaithersburg site fell into this range (Figure 2-22). However, Gaithersburg streams were roughly comparable with the Montgomery County urban sites from the MBSS data set (Figure 2-23).

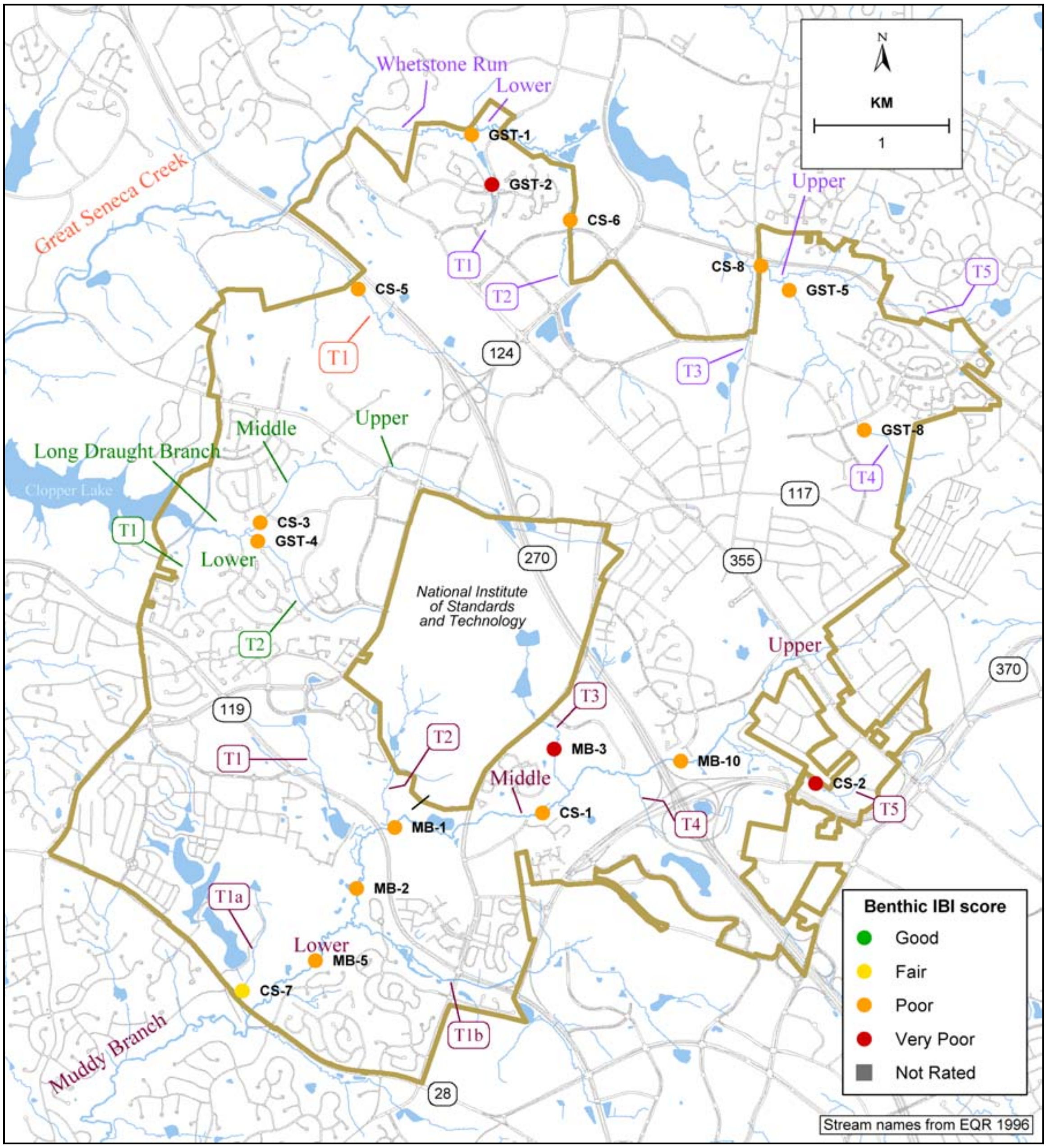


Figure 2-21. Benthic IBI scores for sites sampled in the City of Gaithersburg, 2001-2002

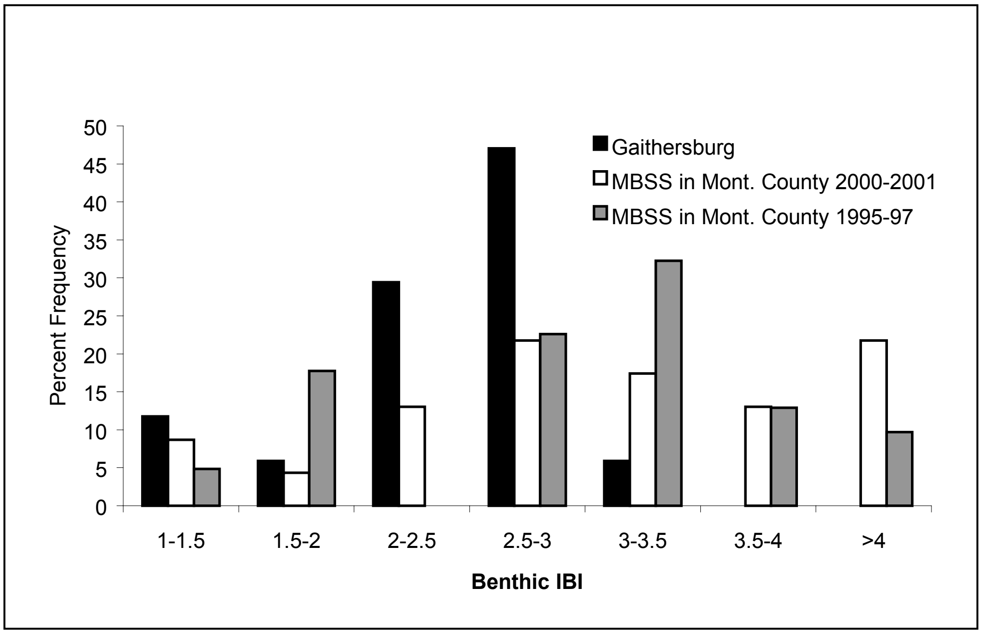


Figure 2-22. Comparison of Gaithersburg 2001-2002 Benthic IBI Results with MBSS Sites in Montgomery County

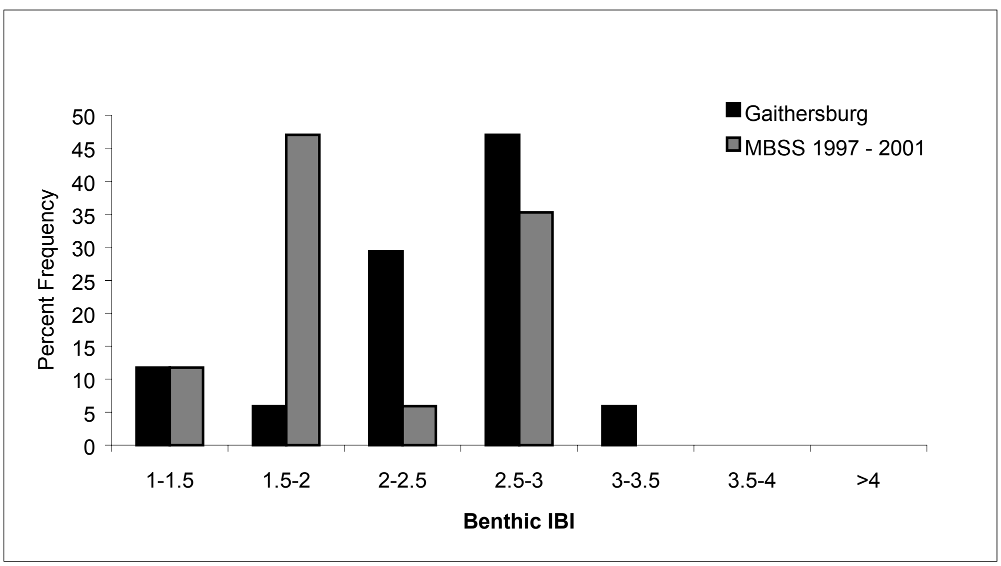


Figure 2-23. Comparison of Gaithersburg 2001-2002 Benthic IBI results with MBSS sites in Montgomery County, MBSS urban sites only

2.2.5 Fish

Electrofishing results from the 16 sites showed that there was noticeable variation in fish assemblages at different stream sites in the City of Gaithersburg. Table 2-21 shows a list of fish species captured, and a tally of individuals. It is noteworthy that the fish captured most often was the bluegill, an exotic (non-native), pond-dwelling species. Bluegill are tolerant of poor water quality and generally inhabit slower-moving pools. Blacknose dace was the second most prevalent fish within the City and is the most abundant freshwater fish species in the state of Maryland (Roth et al. 1999). Some species of particular interest include the banded killifish, which is generally a coastal fish, and the golden shiner, which is a baitfish. It is also interesting to note that two highly common Maryland species, the tessellated darter and redbreast sunfish, were infrequently observed in the City streams.

Table 2-21. Number of individual fish sampled in the City of Gaithersburg 2001-2002 stream assessment, by species

Species	Number
Bluegill	1233
Blacknose dace	831
Green sunfish	490
Central stoneroller	216
Creek chub	213
Longnose dace	201
Brown bullhead	145
Bluntnose minnow	135
White sucker	133
Fantail darter	78
Largemouth bass	61
Banded killifish	50
Silverjaw minnow	38
Golden shiner	31
Pumpkinseed	31
Rosyside dace	28
Yellow bullhead	20
Mosquitofish	19
Greenside darter	9
Redbreast sunfish	4
Tessellated darter	1

Table 2-22 shows the fish bioassessment results for each site, including fish IBI, number of species and individuals found, percent tolerant species, and total biomass. The geographic distribution of Fish IBI scores is shown in Figure 2-24. At all sites sampled, the fish assemblages were dominated by species that can tolerate degraded water quality and habitat. At several sites (GST 2, GST 4, CS 2, CS 6, and CS 7), fish abundance and species richness were quite low. Most of these sites were smaller tributary streams, where the expected number of fish would be low. In fact, the MBSS fish IBI is not used for very small streams (those with catchment area less than 300 acres), because even under reference conditions, few fish would be found. The highest fish IBI scores were found at sites MB 2 and GST 1, which received Fair scores (3.67 and 3.22 respectively). These sites had 15 and 14 species of fish present, respectively, which are good numbers for relatively small streams. The lowest scores were at sites CS 7 in the Muddy Branch watershed (1.67), and at CS 5 and CS 8 in the Great Seneca Tributary watershed (1.89 at both).

Table 2-22. Individual fish metric values and final fish IBI score for sites sampled in the City of Gaithersburg, summer 2002. NR= not rated, because catchment < 300 acres

	Site	Number of Species	Number of Individuals	Percent Tolerant	Biomass (g)	Fish IBI
Random	MB-1	14	472	74.4	1857	3.22
	MB-10	8	191	84.8	711	2.11
	MB-2	15	441	51.7	1161	3.67
	MB-3	6	127	100.0	960	1.89
	MB-5	13	222	65.8	1559	2.56
	GST-1	14	232	87.5	1911	3.22
	GST-2	1	9	100.0	93	NR
	GST-4	5	67	100.0	618	NR
	GST-8	5	320	100.0	2103	NR
	Mean*	9	231	84.9	1219	2.8
Targeted	CS-1	13	511	80.8	2399	2.56
	CS-2	2	19	100.0	46	NR
	CS-3	8	873	97.8	2755	2.33
	CS-5	4	107	55.1	374	1.89
	CS-6	5	62	98.4	227	NR
	CS-7	4	41	95.1	57	1.67
	CS-8	8	289	85.1	1792	1.89

* Mean value for all randomly selected sites; represents the estimated average condition for all streams Citywide.

The data suggest some slight differences when the Muddy Branch and the Great Seneca Tributary watersheds are compared. Muddy Branch, on average, contained a larger number of species (9.3 vs. 6.3), slightly more individuals (253 vs. 245), and a higher IBI (2.52 vs. 2.33) than the Great Seneca Tributary streams did. These apparent differences are likely related to the relatively smaller size of most of the Great Seneca Tributary streams. However, the Great Seneca tributary watershed contained a slightly higher average biomass (1,234 grams vs. 1,094 grams). This would suggest that although Muddy Branch contained more fish and fish species, Great Seneca Tributary contained slightly larger fish species. However, note that in all these comparisons, the small sample sizes do not support a strong conclusion that these areas are in fact different.

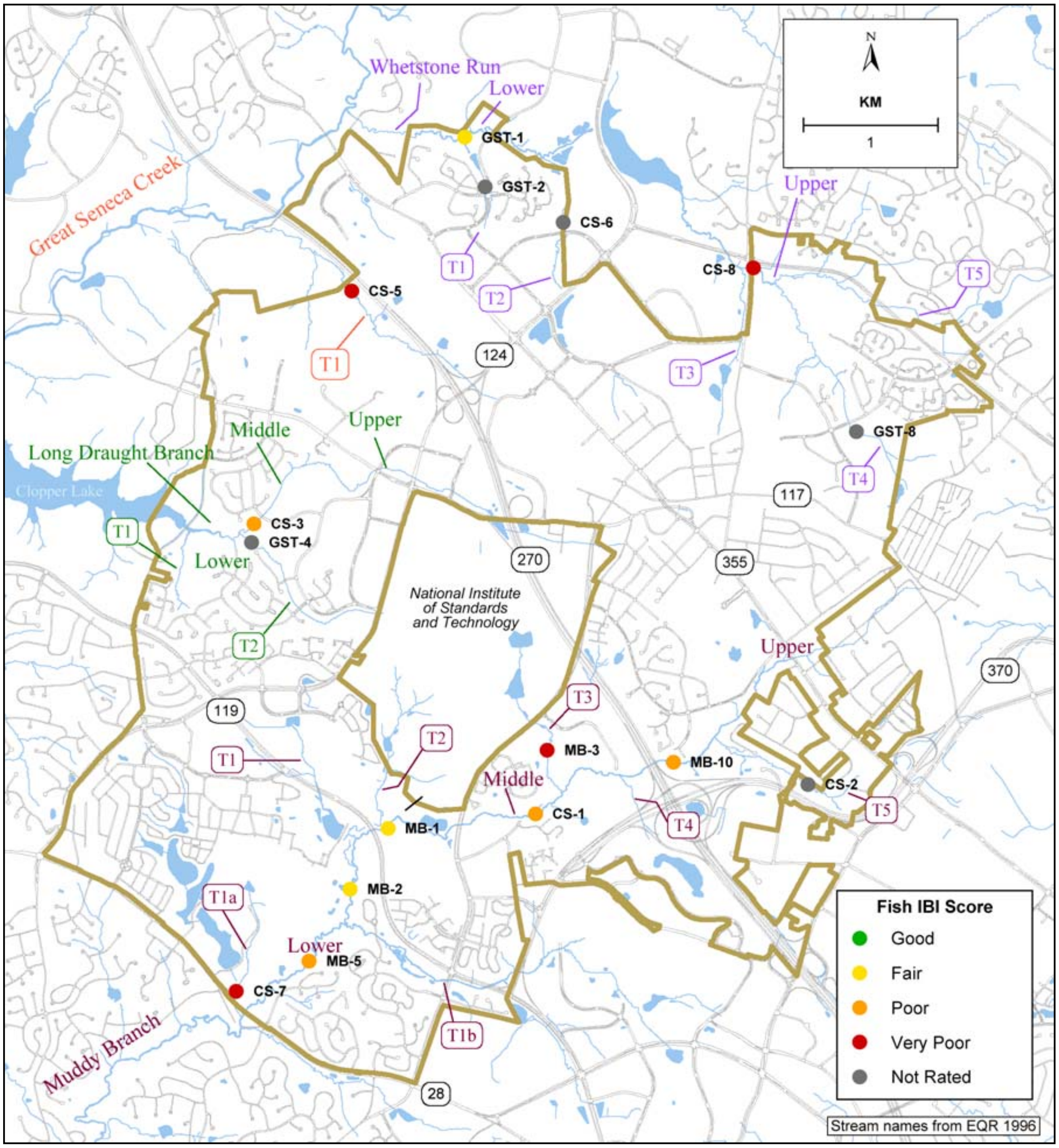


Figure 2-24. Fish IBI scores for the sites sampled in the City of Gaithersburg, 2001-2002. Sites with upstream catchments < 300 acres were not rated by the fish IBI.

Gaithersburg fish IBI results were compared to those from other streams in Montgomery County sampled by MBSS (Figure 2-25). The distribution of scores for Gaithersburg does not include any sites in the Good range (fish IBI > 4), while some sites elsewhere in the County did score in this range. When Gaithersburg sites are compared only with the urban sites in Montgomery County (Figure 2-26), scores were more similar.

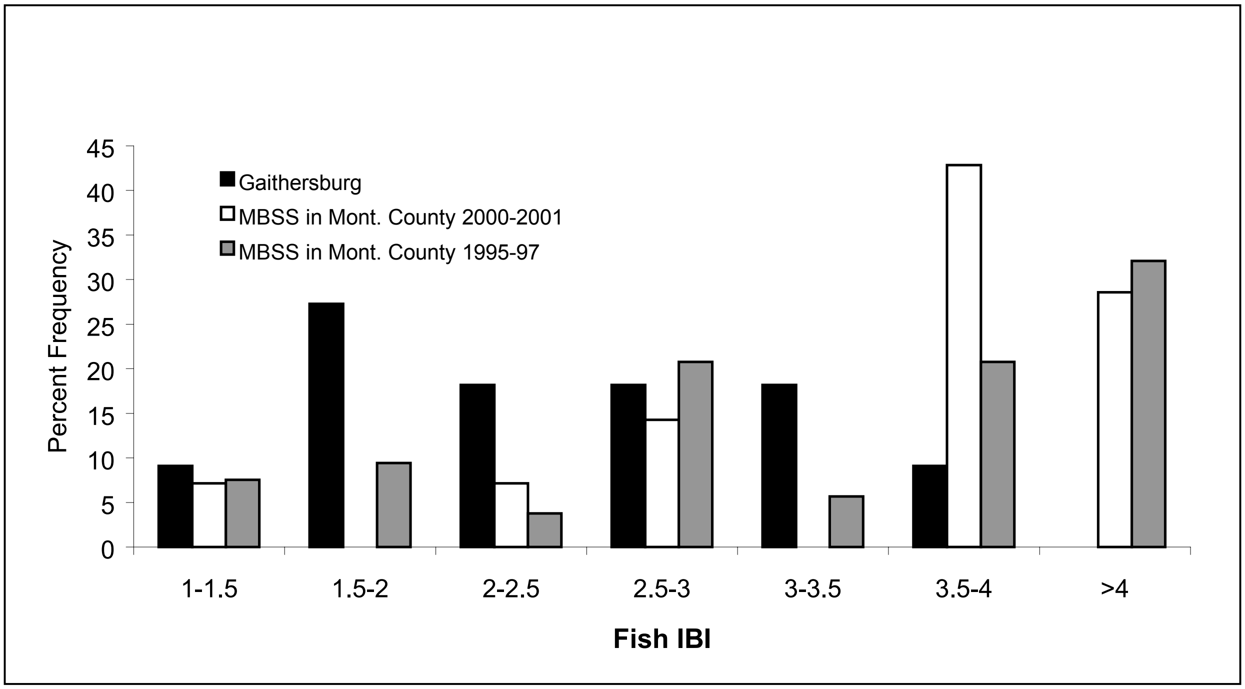


Figure 2-25. Comparison of Gaithersburg 2001-2002 fish IBI results with MBSS sites in Montgomery County

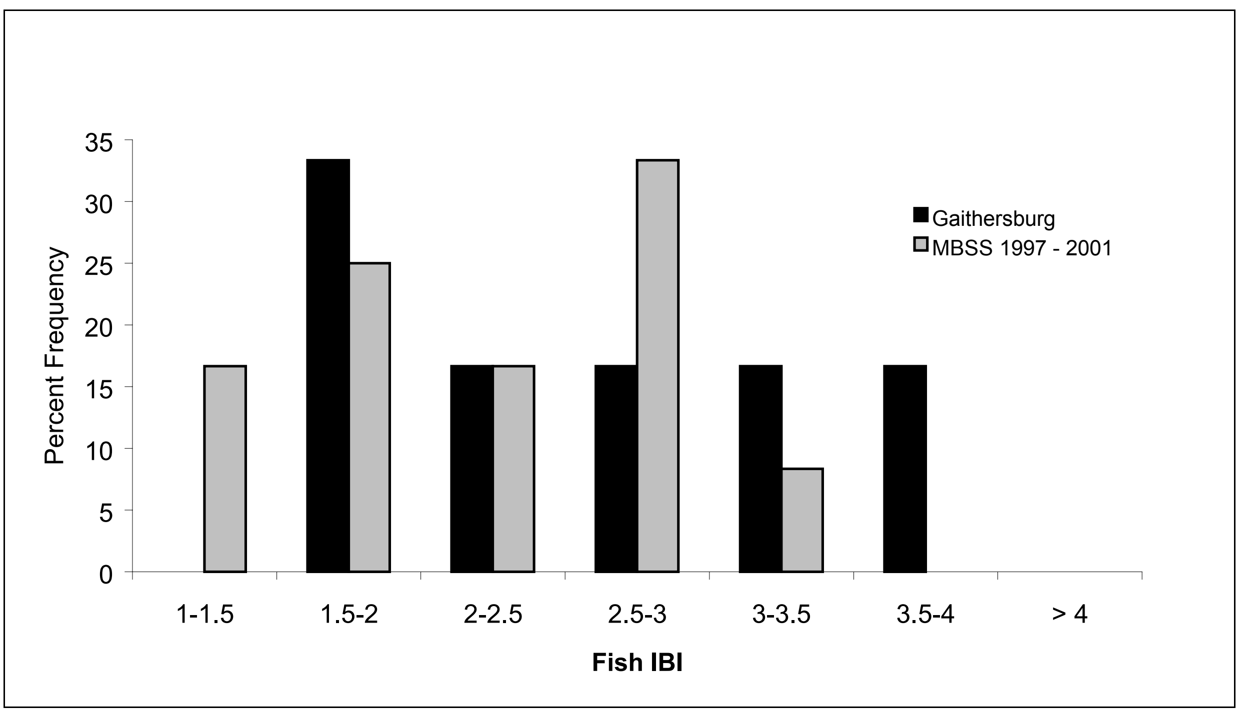


Figure 2-26. Comparison of Gaithersburg 2001-2002 fish IBI results with MBSS sites in Montgomery County, MBSS urban sites only

2.2.6 Relationship of Biology to Landscape Conditions

In order to better understand the relationship between the biology and the land use at each of these sites, the correlations between the benthic and fish IBIs and urban land use was examined. The benthic IBI showed a strong relationship to urban land use (Figure 2-27; $r^2 = 0.61$), decreasing in value as the percentage of urban land in the catchment upstream of the sample location increased. The fish IBI did not show a strong relationship with urban land use ($r^2 = 0.06$) perhaps because some of the sites with the highest percentages of urban land drained catchments too small to be rated with the MBSS fish IBI.

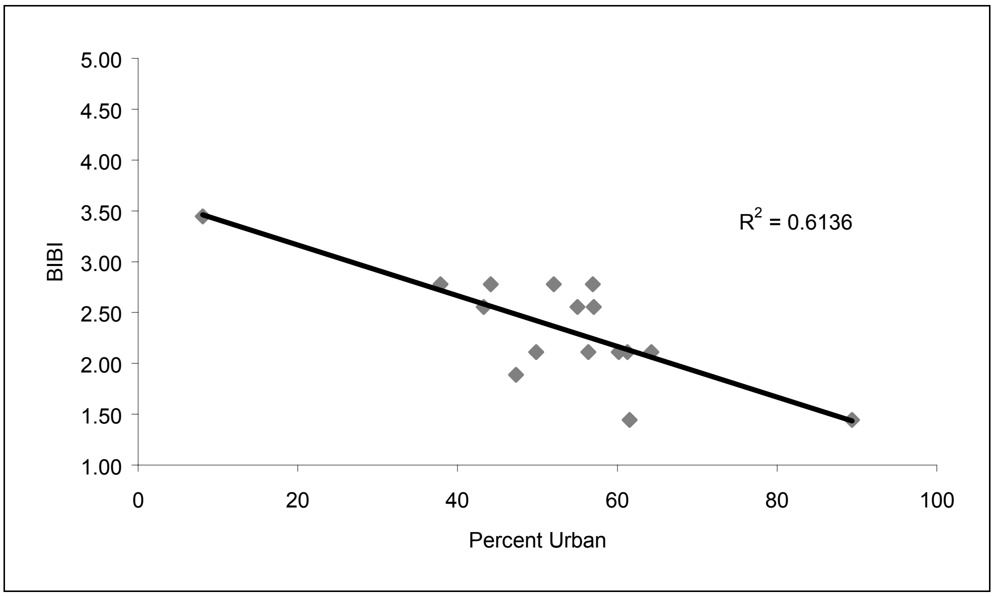


Figure 2-27. Relationship between Gaithersburg 2001-2002 Benthic IBI results and urban land use

2.2.7 Supplemental Results

Rodgers Consulting has performed similar stream monitoring at two sites in Gaithersburg's Lakelands development since 1999. One site (Station One) is located on the mainstem of Muddy Branch, downstream of Great Seneca Highway and Lake Varuna, along Stonemason Drive (near the present study's site MB 2). This site, located upstream of the confluence of the mainstem and the tributary from Washington Woods, was also previously monitored by Montgomery County. The second site (Station Two) is located on the Muddy Branch mainstem just upstream of Great Seneca Highway (near site MB 1). Monitoring by Rodgers involved a morphological survey, water temperature monitoring, and macroinvertebrate sampling. Recent sampling results, summarized by Rodgers (2002), are as follows.

Morphological Survey. Cross sectional surveys showed that between 2000 and 2001, each site had been subjected to changes in stream channel and stream banks. At Station One, the stream channel had moved from the center of the channel towards the right bank. As a result, right bank erosion had increased, enlarging a previously existing undercut on that bank. Station Two also changed greatly between the yearly surveys. At this site, the stream channel widened and shifted to the left. This caused erosion to the left bank, while the right bank gathered deposits, graduating the bank slope (Rodgers 2002).

Water Temperature Monitoring. Rodgers used Stowaway Tidbit Temperature Loggers to collect stream water temperature readings in ten-minute intervals beginning in July and ending in October 2001. Although both monitoring sites had problems with data collection, and no data from either site were available for 2001, data from 1999 and 2000 were presented.

These data showed that temperature data collected in 2000 at both sites were generally lower than observed in 1999. Median temperatures from Site One and at site Two dropped from 21.8 to 19.4 degrees Celsius, and from 22.2 to 18.8 degrees Celsius respectively. The percent of time that state water temperature criteria were not met at each site was also considerably reduced (the state temperature criterion is exceeded when any stream temperature is greater than or equal to 24 degrees C at any point between June 1 and September 30). In 1999, state water temperature criteria were exceeded at Stations One and Two 16.2 and 16.1 percent of the time. However, in 2000, temperatures were much lower, exceeding the criteria only 9.9 and 3.7 percent of the time, respectively.

Benthic Macroinvertebrates. The number of taxa collected at each site in 2001 was lower than the number collected in 1999, reduced from 13 taxa at Station One and 14 taxa at Station Two, to eight taxa at both sites in 2001. However, the number of EPT collected was up from two to three. These data were apparently derived from combining data from both sites. Station One, which was dominated by filter-feeding caddisflies in 1999 (47%), was dominated by pollution tolerant *Baetis* mayfly in 2001 (50%). Dominant taxa at Station Two changed from a filter-feeding caddisfly in 1999 (37%) to midges in 2001 (42%). In any case, each site had a dominant taxon indicative stream degradation.

An increase was also observed in Hilsenhoff's Biotic Index between 1999 and 2001, indicating a greater prevalence of tolerant taxa and suggesting higher levels of organic pollution. Hilsenhoff scores, on a scale of 1 (least tolerant) to 10 (most tolerant), rose from 4.93 and 5.16 in 1999, to 5.81 and 6.46 in 2001 at Stations One and Two. Although no benthic IBI scores were available, the Rodgers monitoring results appear to concur with our assessment, indicating somewhat degraded benthic condition in this portion of the mainstem of Muddy Branch.

2.2.8 Wet Weather Monitoring

In order to evaluate water quality conditions associated with stormwater runoff, the City of Gaithersburg contracted with Versar to conduct wet weather monitoring downstream of a stormwater management facility. This section describes the methods and results for this wet weather monitoring.

The City selected a portion of Tributary 1 of Muddy Branch for monitoring. The three specific sampling locations were:

1. On the tributary draining the Medimmune property, above the nearby road construction near Great Seneca Highway. At the head of this stream is an existing stormwater management structure.

2. On this same tributary, but below Great Seneca Highway, above the confluence with the tributary draining Kentlands Square/Lowe's retail center. This site also receives drainage from Quince Orchard Park and the Highway.

3. Below Great Seneca Highway, below the confluence with the Lowe's tributary but still above the pond at the intersection of Lakelands Drive and Great Seneca Highway.

The following protocols were used to collect samples:

a) A qualifying storm was defined as a rainfall event occurring after a 48-hour time period of dry weather. The storm event was to be at least 30 minutes in duration and at least 0.30" in quantity in a 24-hour period. Because of flow measurement requirements in paragraph (c) below, sampling was only to occur during daylight hours.

b) Water samples were taken within the first half-hour of elevated runoff to be tested for total suspended solids (TSS), settleable solids, turbidity, oil and grease, total phosphorus, and nitrate/nitrite.

c) Onsite, field personnel estimated stream flow rate at the time of collection by using USGS's cross-sectional method of velocity measurements in a transect. In situ measurements of pH, specific conductance, water temperature, and dissolved oxygen were taken.

Sampling was conducted August 28, 2002. Versar field staff were onsite during the "first flush" of the storm event runoff into the waterways of interest. Grab samples were taken for oil and grease, turbidity, solids, and nutrient analysis. Direct water quality measurements (e.g., temperature, pH, dissolved oxygen, specific conductance) were also made at this time. The measured rainfall for this storm event was over one inch (note: 1.43" was recorded at Versar's rain gauge located near Urbana, MD and 2.14" was recorded at Versar's rain gauge located near Cabin John Regional Park). The samples were collected, preserved, and transported according to EPA guidelines. The samples were analyzed by Martel Laboratories of Towson, MD. The field data and analytical results are presented in Table 2-23 below.

The instream water quality measurements were found to be moderate and met the Maryland water quality standards for Use I waters (i.e., water contact, recreation, and protection of aquatic life). Of the three sites sampled, the monitoring site downstream of Medimmune's stormwater retention pond (Site 1) showed the highest dissolved oxygen, lowest pH, lowest temperature, and highest specific conductance.

Table 2-23. Wet weather results from August 28, 2002 storm event at Gaithersburg

Parameters	Site 1 (below Medimmune)	Site 2 (below Great Seneca Hwy, includes Quince Orchard Park and highway drainage)	Site 3 (below Great Seneca Hwy, includes Lowe's retail area drainage)	Units
Instream Water Quality Measurements				
Water Temperature	17.79	20.39	21.17	C
pH	6.95	7.26	7.16	
Dissolved Oxygen	8.1	7.85	7.66	(mg/L)
Specific Conductance	417	135	91	(μmho/cm)
Stream discharge	0.12	1.32	3.96	(cfs)
Chemical Parameters (from Laboratory Analysis)				
Settleable Solids	< 0.3	< 0.3	< 0.3	(mg/L)
Total Suspended Solids	20	65	96	(mg/L)
Turbidity	13	65	120	NTU
Nitrate and Nitrite	0.79	1.2	0.77	(mg/L)
Total Phosphorus	0.14	0.29	0.15	(mg/L)
Oil and Grease	< 2	3	2	(mg/L)

Oil and grease was found at the two downstream sites, consistent with urban stream conditions. In particular, large areas of paved roads and parking lots drain to these sites. Turbidity values were high, but did not exceed the maximum concentration of 150 NTU allowed for Use I waters. The entire storm, however, was not sampled, so these results should only be considered an indication of conditions during the early stages of a storm event.

As a general comparison, these Gaithersburg water chemistry results were compared to results from three rural first order streams near Clarksburg, Maryland (Table 2-24) undergoing development within their watersheds. The type of storm event that was monitored was similar. The nitrate and nitrite concentrations were comparable; however, total phosphorus concentrations in the Gaithersburg streams were an order of magnitude higher than those of Clarksburg. Total suspended solids in the Gaithersburg streams ranged from 10 to 30 times those found at Clarksburg.

Although data are limited to this single storm event, results suggest that water quality in this Muddy Branch tributary is in fact affected by urban development. This was particularly evident in the higher turbidity readings and oil and grease concentrations at the two downstream sites. While no stormwater or sediment controls are 100% effective, management practices in this area should be inspected. Construction sites (including the highway construction above Great Seneca Highway) and stormwater management practices in this drainage should be evaluated to determine whether improvements can be made. Note that the water quality at Site 1 was, at present, slightly better than at the two sites downstream. We recommend re-monitoring during and after construction of the new Medimmune building to determine whether Site 1 continues to support better water quality as development progresses. Further monitoring with a more extensive suite of parameters (e.g., including metals, total petroleum hydrocarbons, fecal coliform, or other indicators) would also provide additional information on water quality.

Table 2-24. Water quality results from December 8, 2001 storm event at Clarksburg Township.

Parameters	Site 1 (confluence)	Site 2 (west trib.)	Site 3 (north trib.)	Site 4 (east trib.)	Units
Instream Water Quality Measurements					
Water Temperature	8.3	8.0	7.5	8.3	C
pH	6.6	6.4	6.7	6.8	
Dissolved Oxygen	9.9	6.9	8.4	9.4	(mg/L)
Specific Conductance	166	374	197	126	(µmho/cm)
Chemical Parameters (from Laboratory Analysis)					
Total Suspended Solids	3	3	2	3	(mg/L)
Nitrate	2.4	1.7	1.1	3.4	(mg/L)
Nitrite	<0.02	<0.02	<0.02	<0.02	(mg/L)
Total Phosphorus	0.03	0.06	0.02	0.02	(mg/L)

2.3 SUMMARY AND CONCLUSIONS

The City of Gaithersburg contains over 24 miles of streams within a highly urbanized area. Some of the features documented by this stream assessment included continuous, if low, perennial stream flows during extended dry summer conditions (although sites were not observed during the extreme low flow of July-August 2002), fair fish diversity and biomass at several sites throughout the city, and reasonable dissolved concentrations of oxygen and water temperature. Several characteristics common to disturbed stream channels were evident within many stream sites. These disturbed stream characteristics included low pH, high conductivity, high turbidity, moderate to severe bank erosion, a degree of high channel incision, extensive channel bar formation, and high percentages of tolerant biota. Indicators for physical habitat, benthic macroinvertebrates, and fish scored predominantly in the Poor range, as shown in a map integrating all indicator results (Figure 2-28).

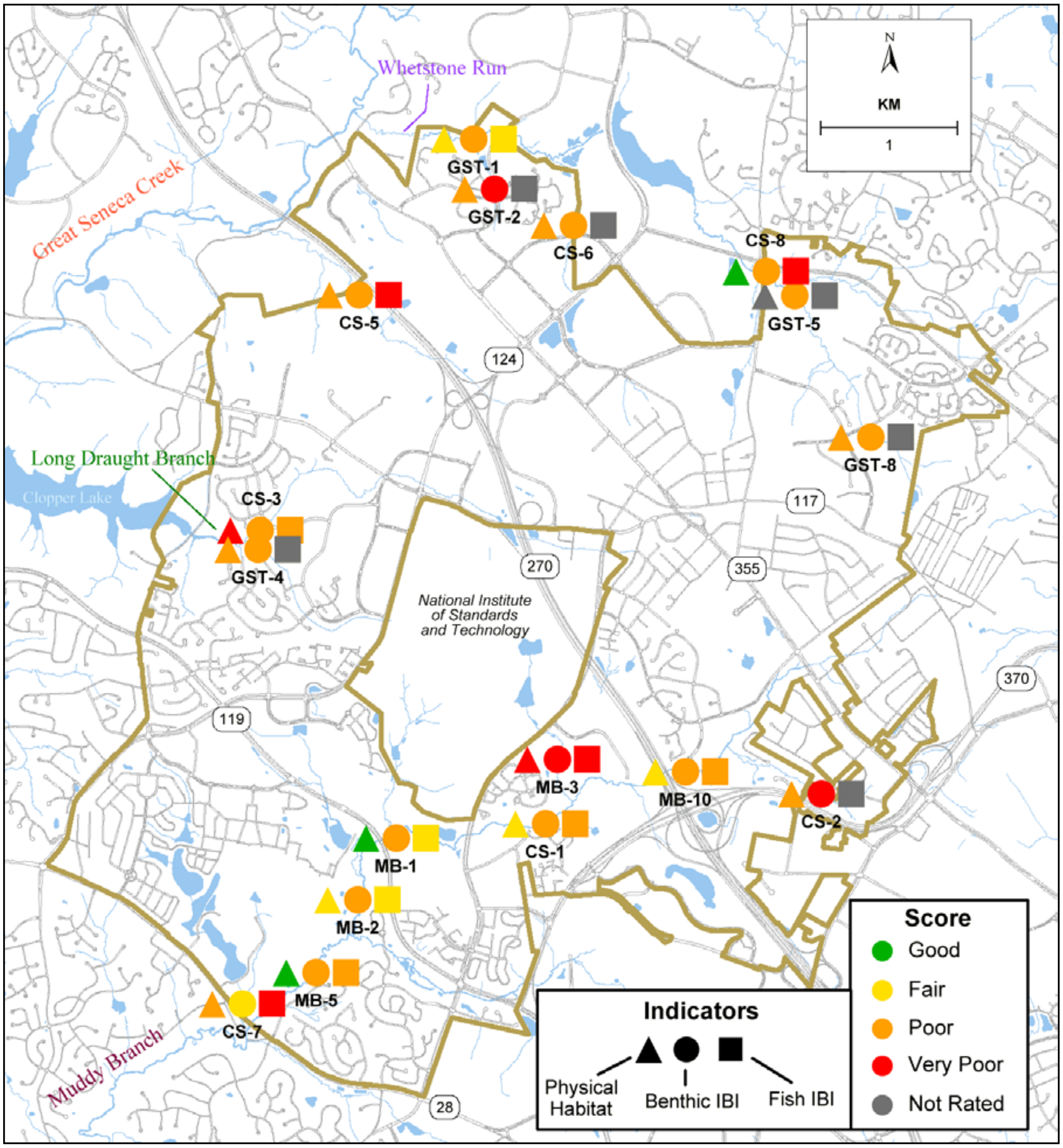


Figure 2-28. Integrated assessment of stream condition, as rated by physical habitat, benthic, and fish indicators, for sites sampled in the City of Gaithersburg, 2001-2002.

3.0 IDENTIFICATION OF AREAS FOR STREAM RESTORATION

Versar assessed City streams to identify segments in need of restoration and to provide City managers with updated and additional information on the best locations to target their restoration efforts. Our approach was to identify those sites within the City of Gaithersburg where restoration would be most cost-effective and would provide the greatest ecological benefit. Utilizing the methods outlined below, Versar worked in collaboration with City personnel to develop a prioritized list of candidate restoration sites. Using this list, we presented the best restoration opportunities based on the unique features of each site.

3.1 METHODS

In order to identify the best opportunities for stream restoration within the City, Versar adapted a restoration targeting approach, successfully employed by Versar in other watershed investigations (Southerland et al. 1999; Southerland et al. 2000; Perot et al. 2002). This approach uses both existing data and new investigations, as follows:

1. Determine general problem types and trends in stream condition
2. Develop criteria within existing information to distinguish problem types
3. Identify areas or sites experiencing degradation and the most likely causes of those problems
4. Develop and apply criteria to rank candidate restoration sites
5. Recommend site-specific restoration measures

As the first step toward characterizing general problem types and planning our subsequent field investigations, we reviewed existing background information on the most significant problems affecting City streams. Available information included (1) a 1996 evaluation of City streams prepared by EQR (1996), (2) biological monitoring surveys previously conducted in the area by the Maryland Biological Stream Survey (MBSS) and Montgomery County Department of Environmental Protection, (3) biological monitoring surveys conducted by Versar as part of this study, and (4) other relevant maps, aerial photographs, and GIS data provided by the City.

To gain further understanding of the general problem types and trends in stream condition, as well as to help develop evaluation criteria, we worked with City staff to determine restoration goals and objectives. Based upon these discussions, we determined that restoration opportunities would be assigned priorities according to factors that included (1) protection of public safety, (2) protection of property and infrastructure, and (3) protection of environment and stream habitat. Furthermore, we determined that restoration concepts should focus, when possible, on stabilization rather than reengineering stream reaches in order to extend limited restoration resources.

The next step in the process involved developing a customized field data sheet to record and rate individual ecological, physical condition, and restoration constraint characteristics. This datasheet was field tested during site selection and Fall Physical Habitat sampling activities for the stream assessment discussed in Section 2. Data sheets were revised accordingly, and an example of the final datasheet may be found in Appendix A.

To evaluate stream conditions and collect data to support the identification of candidate restoration sites, Versar staff conducted detailed visual inspections of the City's streams. Visual inspections were conducted throughout the approximately 24 miles of streams located within the City limits, with the greatest effort directed toward areas most likely to offer restoration opportunities. Field inspections were performed between November 2001 and March 2002 by two-person crews versed in stream ecology and watershed restoration techniques. In addition to the observational data, global positioning system (GPS) coordinates and photographs were recorded at each site. Completed field data sheets for all evaluated sites have been submitted to the City under separate cover.

The following naming conventions were used for the candidate restoration sites. Stream reach and tributary numbers from the1996 EQR study were used to provide consistency between the studies. Candidate restoration sites within the Muddy Branch watershed were designated as MB-1XX and sites within the Great Seneca Tributaries were designated as GST-1XX. Restoration opportunities for the stream monitoring sites (e.g., targeted and randomly selected sites) were also included in this evaluation (e.g., CS-X, MB-0XX, GST-0XX).

Once the visual field inspection of City streams was complete, Versar analyzed the field data. To begin, numerical ratings (1= disagree, 3 = agree) from the field data sheets were tabulated in Excel; entries were double-checked against the original field data sheets as a quality control check. Next, field data were sorted into categories (e.g., severity of stream impacts, degree to which City restoration goals are represented). Several characteristics measured in the field were omitted because they were not useful; additional factors, such as extent of problem, probability of restoration success, and economic feasibility, were added to the analysis to aid in prioritization. Next, site scores were calculated by weighting the average category scores for severity of impact (40% of the total score), extent (20%), City restoration goals (20%), and economic feasibility (20%); that sum was then multiplied by the probability of restoration success (0 to1.0) to derive a total score for each site (maximum possible score = 100), according to the following formula:

$$\text{Total Score} = \left(\begin{array}{c}\text{Severity of Stream}\\ \text{Impacts}\\ \text{(Average/3*40)}\end{array} + \begin{array}{c}\text{Extent of}\\ \text{Problem}\\ \text{(Average/3*20)}\end{array} + \begin{array}{c}\text{City}\\ \text{Restoration}\\ \text{Goals}\\ \text{(Average/3*20)}\end{array} + \begin{array}{c}\text{Economic}\\ \text{Feasibility}\\ \text{(Average/3*20)}\end{array} \right) * \begin{array}{c}\text{Probability}\\ \text{of Success}\end{array}$$

Finally, the threshold for selecting "very good" and "good" restoration opportunities was defined based on a combination of semi-quantitative evaluation and best professional judgment. As is commonly done with ecological data, analysts looked for clear "breaks" in this range of scores (i.e., to denote significant differences in the quality of the restoration opportunity) and then used additional knowledge (especially that obtained in the field) to confirm that the quality of these restoration opportunities was indeed good.

3.2 GENERAL PROBLEM TYPES ENCOUNTERED

Based upon observations in the field, impacts to City streams are widespread. Many of these impacts are related to stormwater runoff, which can result in rapidly fluctuating flow conditions, higher peak flows, and lower base flows, especially in urbanized areas with little to no stormwater controls. Major issues observed in City streams include the following:

Hydrologic modifications: Modification of natural flow regimes associated with historic and current stormwater management practices were the most apparent stressor to the City's watersheds. Development practices have resulted in extensive impervious surfaces and an interconnected system of stormwater drains that rapidly convey and concentrate runoff from large areas. Even in areas where recent development (or re-development) has occurred, few stormwater management facilities exist that sufficiently detain and diffuse the erosive volume and velocity of stormwater runoff within the City.

Erosion and channel destabilization: When development alters natural flow regimes, stream channel instability is often the result. In many portions of the City, stormwater is discharged directly to natural surface drainages through stormdrain outfalls frequently located in areas where steep slopes increase the velocity and erosive power of the concentrated flows. These hydrologic modifications often upset the dynamic equilibrium among velocity, flow resistance, stream discharge, sediment size, and sediment load that influences channel morphology (i.e., channel width, depth, and slope) in natural stream channels (Nunnally 1978; Rosgen 1993). The increased erosive power of stormwater within the City has caused stream channels to respond to the disrupted equilibrium by incision, headcutting, gravel bar formation, sedimentation, and other channel adjustments. Once the equilibrium has been upset, it can often take several decades to reestablish a balance–one that could look and behave very differently than before. It is also possible that a morphologically stable channel may not develop, even after a considerable time (Keller 1975, 1978).

Nonpoint source pollution: In addition to the ensuing stream channel destabilization, nonpoint source pollutants (e.g., sediment, pesticides and herbicides, fertilizers, pet wastes, heavy metals) washed from roads, rooftops, and lawns are rapidly conveyed through the stormdrain network into the City's streams. This effectively bypasses the network of riparian buffers found along many portions of the City's streams and eliminates much of their natural filtering and stormwater retention capacity. Therefore, surface water quality may be degraded.

Channelization: Another modification of natural flow regimes involves straightening, armoring, and even burying stream channels, as was evident in a number of stream channel segments within the City. Because channelization frequently prevents localized channel adjustments that might compensate for changes in equilibrium, stresses are typically passed on to unchannelized segments, where they can lead to destabilization of the channel above and below the hardened segment.

The driving forces behind these channel adjustments will need to be addressed (through stormwater retrofits and best management practices) before long-term stability of the stream channel can be achieved; however, stream stabilization efforts discussed below are likely to reduce the effects of these disturbances and be beneficial in the meantime.

3.3 SITE-SPECIFIC RESTORATION OPPORTUNITIES

Fifty-two candidate restoration sites were identified in the field surveys. Table 3-1 summarizes the numerical ratings for each of these sites and ranks each according to their restoration opportunity. Although these rankings are based on a number of important factors, we anticipate that the City will ultimately choose final restoration sites based on integrating these results with other information, including data not currently available. For this reason, individual scores for each parameter are shown in Table 3-1. Final scores ranged from 25.3 to 65.5. The locations of these candidate restoration sites are shown in Figure 3-1.

3.3.1 Top 10 Candidate Sites for Restoration

Sites identified as having very good restoration opportunities in Table 3-1 were considered the best candidates for stream restoration. As such, we have prepared the following information to describe site conditions, identify potential approaches to fix identified problems, and provide rough cost estimates for planning purposes. Cost information has been gathered from a number of sources, including the Center for Watershed Protection (1998), Haupt et al. (2002), and the Rouge Program Office (2001). Although the level of detail provided by these three sources varied, the following cost estimates generally included consideration of engineering, design, and construction costs. Haupt et al. (2002) provided the most detailed breakdown of project costs and provided an average total cost estimate of $218 per linear foot for urban stream restoration projects in North Carolina, which included costs for site identification and acquisition, design, construction and construction management, post-construction monitoring and maintenance, and long-term management. Note that costs may vary depending on location, accessibility, whether or not land purchase is required, and other site-specific factors. The estimates below are intended for general planning purposes only.

Table 3-1. Candidate stream restoration sites within the City of Gaithersburg, MD

			Severity of Stream Impacts: Hydrologic Modifications			Severity of Stream Impacts: Channel Condition						Severity of Stream Impacts: Instream habitat						Severity of Stream Impacts: Riparian habitat				Severity of Stream Impacts: Water quality						Extent of Problem		City Restoration Goals					Economic Feasibility				Probability of Success
Restoration Opportunity	Site No.	Total Score (max. 100)	Impairment from blockages	Impairment from stormdrain or other pipes	Impairment from channel alterations	Excessive sediment deposition	Excessive bar formation	Unstable substrate	Accelerated lateral channel migration	Channel downcutting	Widespread bank instability/ erosion	Heavily silted substrate	Lack of instream fish cover	Lack of epifaunal substrate	Lack of woody debris	Lack of bank vegetative protection	Poor stream shading	Narrow buffer width	Breaks in buffer	Vegetation showing signs of stress	Existing wetlands adjacent to area	Excessive algae	Organic scum	High turbidity	Obvious spills, discharges, plumes, odors	Trash problems	Category Score (max. 40)	Relative extent of problem widespread = 3 localized = 1	Category Score (max. 20)	Safety issues	Infrastructure threatened	Infrastructure damaged	Adjacent properties severely impacted	Category Score (max. 20)	Site on City-owned land	Suitable access for equipment	Relative potential costs low = 3 moderate = 2 high = 1	Category Score (max. 20)	Likelihood of restoration success certain = 1 none = 0
Very Good	MB-115	65.50	1	1	1	3	3	3	3	3	3	3	3	3	3	3	2	1	1	1	3	1	1	1	1	2	27.78	3	20	2	2	1	2	11.67	2	3	1	13.33	0.9
	MB-111	64.50	3	1	2	3	3	3	3	3	2	1	1	3	1	2	2	2	2	1	1	2	1	1	1	2	25.56	2	13.33	2	3	2	2	15	3	3	2	17.78	0.9
	MB-114	64.00	3	1	1	3	3	2	3	2	3	1	2	3	1	3	3	2	1	1	3	1	1	1	1	3	26.67	2	13.33	3	1	1	3	13.33	2	3	3	17.78	0.9
	GST-105	61.50	3	3	3	3	3	2	2	2	3	2	2	2	2	1	1	1	2	1	1	2	2	1	2	3	27.22	3	20	3	1	1	1	10	2	2	1	11.11	0.9
	GST-101	60.50	3	2	2	3	3	3	2	3	3	2	1	2	1	3	2	3	2	1	1	2	1	1	1	2	27.22	2	13.33	2	2	1	3	13.33	2	3	1	13.33	0.9
	GST-106	59.00	3	1	2	2	2	1	2	1	2	2	2	1	1	3	2	3	3	1	1	1	2	1	1	2	23.33	1	6.67	3	3	3	3	20	2	3	2	15.56	0.9
	MB-112	58.00	1	1	1	3	3	3	2	1	1	3	2	2	1	1	2	2	1	1	3	1	1	1	1	3	22.78	2	13.33	1	2	1	1	8.33	3	3	3	20	0.9
	MB-108	58.00	3	1	1	2	1	2	3	2	2	2	1	1	1	2	1	2	1	1	1	1	1	3	1	3	21.67	1	6.67	3	3	3	2	18.33	3	3	2	17.78	0.9
	GST-112	55.22	1	3	3	1	2	3	3	1	3	2	3	3	2	3	2	3	2	1	1	1	1	1	2	3	27.78	2	13.33	3	3	3	3	20	3	3	2	17.78	0.7
	MB-104	55.00	3	1	2	2	2	2	3	2	2	2	3	2	3	3	2	2	2	1	3	3	2	2	1	2	28.89	1	6.67	3	1	1	1	10.00	2	3	2	15.56	0.9
Good	GST-120	53.50	1	3	1	1	2	2	3	3	2	1	1	1	1	2	1	1	1	1	1	1	1	1	1	2	19.44	1	6.67	2	3	2	1	13.33	3	3	3	20.00	0.9
	MB-102	53.28	1	3	3	3	3	3	3	3	3	2	2	2	1	3	1	1	3	3	1	1	2	1	1	1	27.78	3	20	3	3	1	2	15.00	2	3	1	13.33	0.7
	CS-001	53.28	3	2	3	3	3	2	3	1	3	3	1	1	1	2	1	1	3	1	3	2	2	2	1	2	27.22	3	20	3	3	1	1	13.33	3	3	1	15.56	0.7
	GST-117	53.00	3	1	1	3	1	1	1	1	1	3	2	2	2	1	1	1	1	1	3	1	1	1	1	3	20.56	1	6.67	2	3	1	1	11.67	3	3	3	20	0.9
	MB-116	52.50	1	1	1	3	3	3	3	2	3	2	2	2	1	3	2	2	2	1	1	1	1	1	1	2	24.44	1	6.67	2	1	1	3	11.67	1	3	3	15.56	0.9
	GST-121	52.00	1	1	1	3	3	3	3	1	3	2	2	2	2	2	1	3	1	1	1	1	1	2	1	2	23.89	1	6.67	1	3	2	1	11.67	3	3	1	15.56	0.9
	GST-118	51.50	1	1	1	1	1	2	3	2	1	1	1	1	1	2	2	2	2	1	1	2	1	1	1	2	18.89	1	6.67	1	3	2	1	11.67	3	3	3	20	0.9
	GST-119	51.50	1	1	1	1	1	3	1	3	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3	17.22	1	6.67	2	3	1	2	13.33	3	3	3	20	0.9
	MB-113	50.94	1	1	1	3	3	3	3	3	3	1	3	3	2	3	2	1	1	1	1	1	1	1	1	2	25	2	13.33	2	3	3	2	16.67	3	3	2	17.78	0.7
	MB-010	50.50	1	1	2	3	3	3	1	1	1	3	3	3	2	3	1	2	3	2	1	1	1	1	1	2	25	1	6.67	1	1	1	1	6.67	3	2	3	17.78	0.9
	MB-110	47.06	1	1	3	3	3	3	3	2	3	2	1	1	2	3	2	3	1	1	1	1	1	3	1	2	26.11	2	13.33	2	1	1	2	10	3	3	2	17.78	0.7
	GST-113	47.06	3	3	1	3	2	2	3	3	3	3	3	3	3	3	2	1	1	1	2	2	1	3	1	2	30	1	6.67	1	3	3	2	15	3	3	1	15.56	0.7
	GST-116	46.67	1	2	1	2	3	2	3	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1	2	2	23.33	2	13.33	2	3	2	3	16.67	2	3	1	13.33	0.7
	MB-105	45.50	3	1	1	2	1	1	1	1	1	2	1	1	1	1	1	1	1	1	3	1	1	1	1	1	16.67	1	6.67	2	2	2	1	11.6667	1	3	3	15.56	0.9
	MB-106	44.72	1	2	1	3	3	3	3	2	3	2	3	3	2	3	1	1	1	1	2	1	1	1	1	2	25.56	2	13.33	1	3	2	1	11.67	2	3	1	13.33	0.7
Moderate	CS-006	44.00	1	2	2	2	1	1	1	2	2	2	1	1	1	2	1	2	3	2	1	1	1	1	1	2	20	1	6.67	1	1	1	1	6.67	2	2	3	15.56	0.9
	CS-003	43.56	3	3	3	2	1	3	1	3	3	3	3	3	3	2	3	3	3	2	1	1	1	1	3	2	31.11	1	6.67	1	1	1	1	6.67	3	3	2	17.78	0.7
	GST-004	43.50	1	1	3	2	2	1	1	2	3	2	2	1	2	2	1	2	3	1	1	1	1	1	1	2	21.67	1	6.67	1	1	1	1	6.67	3	1	2	13.33	0.9
	GST-104	43.17	3	3	1	2	1	1	1	2	2	2	3	2	2	2	3	3	2	1	1	1	1	1	1	2	23.89	2	13.33	1	1	1	1	6.67	2	3	3	17.78	0.7
	MB-006	42.78	1	3	3	2	1	3	1	3	2	2	3	3	3	3	2	3	3	1	1	2	2	1	3	3	30	2	13.33	1	1	1	1	6.67	1	3	1	11.11	0.7
	GST-008	42.00	3	3	2	2	1	3	1	1	1	2	3	3	2	3	2	3	3	3	2	1	2	2	1	3	28.89	1	6.67	1	1	1	1	6.67	3	3	2	17.78	0.7
	GST-114	42.00	1	1	1	3	2	2	3	2	3	3	3	3	3	3	3	1	1	1	3	1	1	3	1	1	27.22	1	6.67	1	2	1	1	8.33	2	3	3	17.78	0.7
	MB-109	41.50	1	1	1	1	3	2	2	1	2	1	1	1	1	2	1	1	1	1	3	1	1	1	1	1	17.78	1	6.67	2	1	1	1	8.33	2	1	3	13.33	0.9
	GST-002	41.22	3	3	3	2	2	2	1	3	3	1	3	2	3	3	3	3	3	2	1	1	2	1	1	3	30	1	6.67	1	1	1	1	6.67	3	2	2	15.56	0.7
	GST-107	39.67	1	2	2	2	2	1	3	2	2	3	2	2	1	2	1	1	3	1	1	1	1	2	1	1	22.22	1	6.67	1	3	1	1	10	2	3	3	17.78	0.7
	GST-102	38.50	1	3	1	3	3	3	3	3	3	2	3	3	2	3	2	1	3	2	1	1	1	1	1	2	28.33	1	6.67	1	1	1	1	6.67	2	3	1	13.33	0.7
	MB-101	38.11	2	1	1	2	1	1	1	2	1	2	1	1	1	1	2	1	2	1	3	1	1	1	1	2	18.33	1	6.67	2	3	1	1	11.67	2	3	3	17.78	0.7
	GST-006	37.72	1	1	1	1	1	2	1	3	3	3	3	3	3	3	3	3	3	3	1	1	1	1	1	3	27.22	1	6.67	1	1	1	1	6.67	1	3	2	13.33	0.7
	GST-001	36.94	1	1	1	3	1	3	1	3	2	2	3	2	1	3	3	3	1	2	2	1	1	1	1	2	24.44	1	6.67	1	2	1	1	8.33	2	2	2	13.33	0.7
	GST-111	36.17	1	1	1	2	3	3	3	2	3	1	2	3	1	2	1	2	1	1	1	2	1	1	1	1	22.22	1	6.67	1	3	1	2	11.67	1	3	1	11.11	0.7
	MB-107	35.78	1	1	1	2	3	2	2	2	2	2	1	1	1	2	1	1	1	1	1	1	1	3	1	2	20	2	13.33	1	1	1	1	6.67	1	3	1	11.11	0.7
	GST-109	35.39	1	3	1	2	3	2	2	2	2	2	1	2	1	3	2	2	1	1	1	1	1	1	1	2	22.22	1	6.67	2	1	1	1	8.33	1	3	2	13.33	0.7
	MB-103	33.06	1	2	1	3	3	3	3	3	3	3	3	3	2	3	1	1	1	1	1	3	2	1	1	2	27.78	2	13.33	3	2	1	1	11.67	2	3	1	13.33	0.5
	MB-003	31.89	1	1	1	1	2	2	1	1	1	1	2	1	1	1	1	2	2	1	1	3	2	1	1	3	18.89	1	6.67	1	1	1	1	6.67	1	2	3	13.33	0.7
	CS-002	29.72	1	1	1	3	3	2	3	3	3	2	2	2	2	2	1	1	1	2	1	1	2	1	2	2	24.44	2	13.33	1	2	1	1	8.33	3	2	1	13.33	0.5
	MB-005	28.61	1	1	1	1	3	1	2	2	2	1	1	3	2	2	2	1	1	1	2	1	1	1	1	1	19.44	3	20	1	1	1	1	6.67	2	2	1	11.11	0.5
	GST-115	28.06	1	3	1	2	2	2	3	3	3	2	3	1	1	2	2	2	1	1	1	1	1	1	2	2	23.89	1	6.67	1	1	1	3	10	1	3	3	15.56	0.5
	GST-005	27.22	1	1	2	3	2	1	3	2	2	2	1	2	1	2	1	2	1	2	3	1	1	2	1	3	23.33	1	6.67	1	1	1	1	6.67	3	3	2	17.78	0.5
	GST-110	26.94	1	2	1	1	3	2	2	1	2	1	2	1	1	2	1	1	1	1	1	1	1	1	1	2	18.33	2	13.33	1	1	1	1	6.67	3	3	1	15.56	0.5
	MB-001	26.94	3	1	1	1	1	1	1	1	1	1	1	1	2	2	1	1	1	1	1	1	1	1	1	2	16.11	3	20	1	1	1	1	6.67	2	2	1	11.11	0.5
	MB-002	26.39	1	1	3	2	3	1	1	1	2	1	2	1	3	1	2	2	3	1	1	1	1	1	1	1	20.56	2	13.33	1	3	1	1	10	1	2	1	8.89	0.5
	CS-005	25.28	1	1	1	3	3	2	3	3	3	2	2	2	1	3	1	1	1	1	3	1	1	1	1	2	23.89	1	6.67	1	1	1	1	6.67	2	3	1	13.33	0.5
	Max Possible Score	100.00	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	40	3	20	3	3	3	3	20	3	3	3	20	1

Notes:

Numerical ratings were assigned on a scale from 1 (disagree) to 3 (agree), unless otherwise noted

$$\text{Total Score} = \left(\begin{array}{c}\text{Severity of}\\ \text{Stream Impacts}\\ \text{(Average/3*40)}\end{array} + \begin{array}{c}\text{Extent of}\\ \text{Problem}\\ \text{(Average/3*20)}\end{array} + \begin{array}{c}\text{City}\\ \text{Restoration}\\ \text{Goals}\\ \text{(Average/3*20)}\end{array} + \begin{array}{c}\text{Economic}\\ \text{Feasibility}\\ \text{(Average/3*20)}\end{array} \right) * \begin{array}{c}\text{Probabili}\\ \text{of}\\ \text{Succes}\end{array}$$

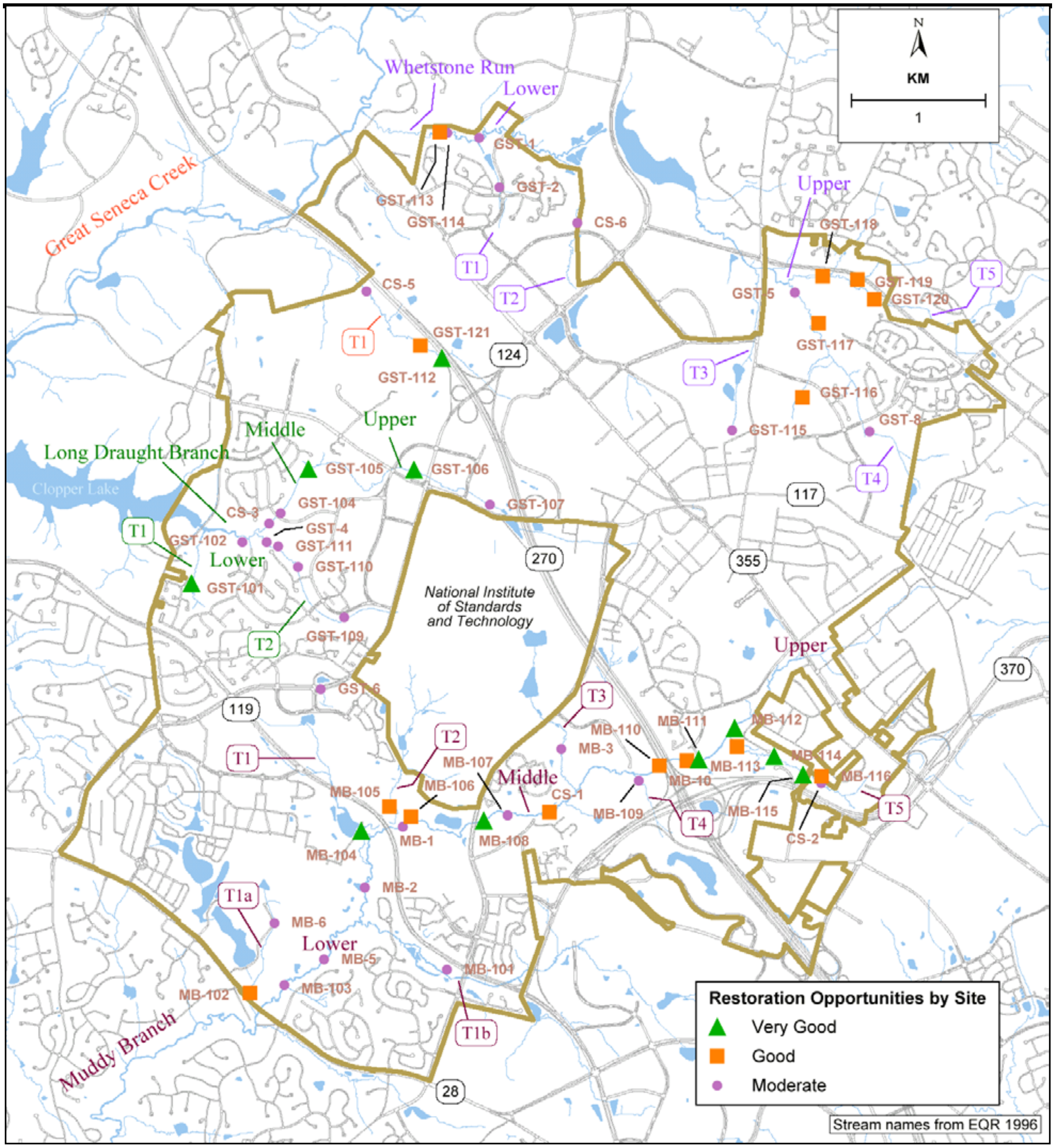


Figure 3-1. Candidate stream restoration sites within the City of Gaithersburg, MD

Top 10 Stream Restoration Candidate Sites	
Site No.:	MB-115
Site Score:	65.50
Location:	Muddy Branch, tributary 5, northeast of I-370
Site Description:	Runoff via culvert from I-370 has blown out ephemeral channel, now 3m wide, 2m deep, and approximately 40m long (Figure 3-2). This has exacerbated meandering of Tributary 5 and led to extensive sediment deposition within channel. The meander belt is approximately 30m wide with 1m high terraces (Figure 3-3).

Figure 3-2

Figure 3-3

Restoration Approach:	The State Highway Administration (SHA) should be notified that stormwater runoff from the highway is causing major channel instability at this location. The volume, frequency, and flashiness of runoff should be reduced to prevent further problems with the receiving channel. Structures to encourage infiltration and detain runoff should be constructed near the highway to control runoff. In addition, restoration efforts in the destabilized channel should include recreation of the stream channel using nearby reference reaches as a template for designing stable channel dimensions, patterns, and profiles[1], stabilizing the banks with vegetation, and installing grade control structures to prevent further incision of the channel.
Approximate Cost:	$200,000 - $400,000

[1] Channel dimensions include such measures as bankfull width/depth ratio, bankfull cross-sectional area, and slope; channel patterns include straight, meandering, or braided forms; and stream profiles include both cross-sectional and longitudinal.

Site No.: MB-111
Site Score: 64.50
Location: Muddy Branch (upper), near Summit Hall Elem. School in Morris Park

Site Description: Undercut streambank (30m long and 1m high) will soon topple a tree into the footbridge crossing the stream near Summit Hall Elementary School in Morris Park (Figure 3-4). Log in stream has created a plunge/scour hole immediately upstream of sewer line crossing, and 3m high, eroded bank.

Figure 3-4

Figure 3-5

Restoration Approach: To protect the footbridge, the undercut tree should be removed and this section of the outer streambank should be stabilized with vegetated riprap[2]. The log in the stream above the sewer line should be removed to prevent the scour hole from undermining the sewer line. The steep bank at this location should also be cut back and stabilized with vegetation.

Approximate Cost: $5,000 - $15,000

[2] Vegetated riprap consists of live stakes (e.g., willow, black alder) inserted through riprap and into the soil near the saturated zone; roots that grow from the live stakes stabilize the bank and provide riparian vegetation.

Site No.: MB-114
Site Score: 64.00
Location: Muddy Branch, tributary 5, Edgewood Ct.

Site Description: Debris jam in stream 15m from house poses safety hazard, particularly during high flows (Figure 3-6). Tortuous bend in stream has formed extensive gravel bar and will continue to trap debris until meander bend is cut off (bank currently undercut and likely to fail within 2-4 years).

Figure 3-6

Restoration Approach: The large, fallen tree embedded in the gravel point bar should be left in place because it is trapping sediment, protecting the streambank nearest the houses, and aiding sediment transport through this bend. Smaller debris in the main channel should be removed. The undercut bank located across the stream and above the tree should be stabilized with riprap to prevent further erosion. Periodic inspections and maintenance should be conducted at this location to remove accumulated debris should it become a problem.

Approximate Cost: $2,500 - $5,000

Site No.: GST-105
Site Score: 61.50
Location: Long Draught (middle), along Clopper Road

Site Description:

- Failed in-stream stormwater management structure between Noble Wood Ct. and Twelve Oaks Dr. has undermined gabion blankets, exposed pipes, and trapped large quantities of sediment, trash, and debris (Figure 3-7). This situation poses an extreme safety hazard.

Figure 3-7

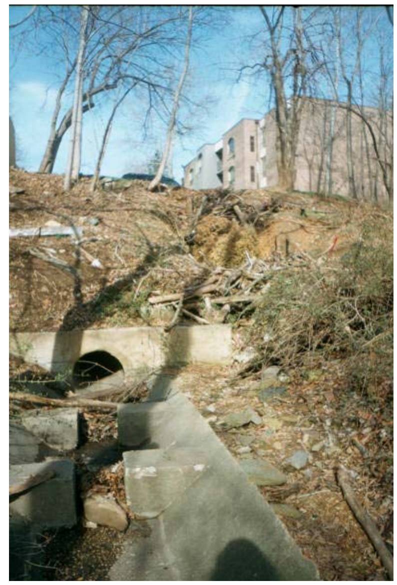


Figure 3-8

- Runoff from residential parking lot has bypassed outfall and eroded hillside (Figure 3-8).

- Retaining wall of apartment building threatened by lateral stream channel erosion, and children using iron fence to cross stream in park immediately downstream from Clopper Road crossing (Figure 3-9). Nearby footbridge in park has been undermined by erosion (Figure 3-10).

Figure 3-9

Figure 3-10

Restoration Approach:	(1) The failing in-stream SWM structure should be removed and stable channel dimensions, patterns, and profiles should be reestablished at this location. Banks should be stabilized with vegetation and geotextile materials as necessary. (2) To prevent runoff from overtopping the curb at the corner of this parking lot, the curb should be built up higher. Site SWM controls should be retrofitted to slow and reduce runoff volumes. In addition, the gully eroded into the hill should be filled, using geotextile materials and live plantings to stabilize the surface. (3) Riprap should be used to provide additional protection for the retaining wall at the apartment building and very large riprap could be placed in the stream to provide stepping stones as a crossing rather than the iron railing currently being used. (4) The footbridge should be stabilized with additional fill and concrete, as needed, and a riparian buffer should be established along this reach.
Approximate Cost:	(1) \$100,000 - \$250,000, (2) \$2,500 - \$5,000, (3) \$2,500 - \$5,000, (4) \$5,000 - \$10,000

Site No.: GST-101
Site Score: 60.50
Location: Long Draught, tributary 1, below Cullinan Dr.

Site Description:

- Steep, eroded streambank behind houses on Melmark Ct. showed signs of active erosion (4m high banks located 10m from houses) (Figure 3-11). This erosion appears to be related more to a lack of vegetative cover and possibly an unstable angle of repose than from the adjacent stream. In any case, eroded sediment is likely to reduce water quality and stream habitat.

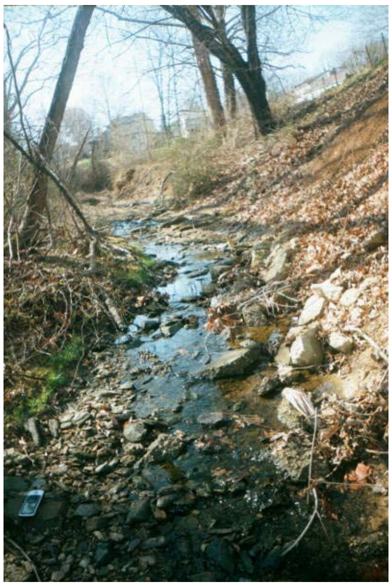


Figure 3-11

Figure 3-12

- Log dam near Seneca Creek State Park boundary is in disrepair and has a large scour hole below structure (Figure 3-12).
- Very large meander with scour and undercut banks will cut off bend (approximately 2-4 years) (Figure 3-13).
- WSSC sewer line encased in concrete acts as a dam/weir and blocks the stream channel at the confluence with Clopper Lake (Figure 3-14).

Figure 3-13

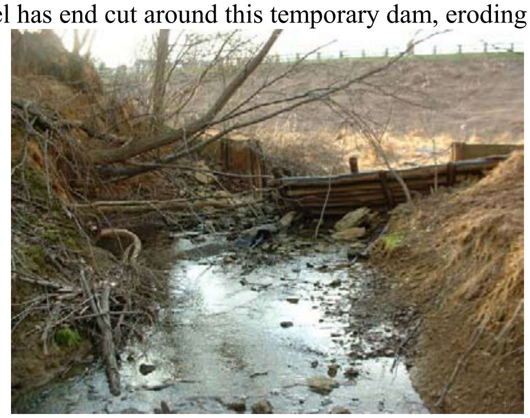
Figure 3-14

Restoration Approach:	(1) Stabilize the steep slope behind the houses on Melmark Ct. with a cellular geotextile fabric (e.g., geogrid) and revegetate with native vegetation. (2) Remove the log dam to allow for adequate transport of both water and sediment through the stream channel at this location. Reestablish stable channel dimensions, patterns, and profiles. Vertical drops in the stream channel formed by scour at the old dam could be stabilized by creating a step pool type channel morphology (using large rock to line the bottom of the step pools to diffuse energy). Stabilize banks by planting native vegetation. (3) Reprofile and stabilize streambanks, using vegetated riprap on outside bends and native vegetation on inside bends. (4) Modify sewer line crossing to allow low-flow fish passage.
Approximate Cost:	(1) \$10,000 - \$15,000, (2) \$15,000 - \$30,000, (3) \$10,000 - \$20,000, (4) \$5,000 - \$15,000

Site No.:	GST-106
Site Score:	59.00
Location:	Long Draught (upper) at Clopper and Quince Orchard Roads
Site Description:	End cut around an old bridge culvert still in place, with erosion breaching a 4m-high, earthen berm/levee adjacent to the stream above the old bridge structure (Figure 3-15). The break in the berm brings the stream within 9m of an apartment building. A debris jam is located upstream of the berm, and a long, straight stretch of stream, with poor buffer, is located below the old bridge.  Figure 3-15
Restoration Approach:	Integrate restoration into proposed SHA project to widen Clopper Road. At a minimum, the old bridge structure should be removed, reestablishing stable channel dimensions, patterns, and profiles. The slope of the adjacent berm is too steep and should be laid back, and if necessary stabilized with geogrid, to provide a more stable slope. In addition, a riparian buffer containing a variety of native woody and herbaceous plants should be established along this section of stream.
Approximate Cost:	$15,000 - $30,000

Site No.:	MB-112
Site Score:	58.00
Location:	Muddy Branch (upper), behind Summit Hall Elem. School in Morris Park
Site Description:	Bank erosion has exposed a sewer manhole (Figure 3-16). Riprap immediately upstream of the manhole is insufficient protection. Trash and other debris also pose a nuisance hazard to schoolchildren.  Figure 3-16
Restoration Approach:	Place additional riprap around exposed surfaces of the manhole to replace lost material. Clean up trash in this area, leaving some woody debris as habitat for stream organisms.
Approximate Cost:	$1,500 - $2,500

Site No.:	MB-108
Site Score:	58.00
Location:	Muddy Branch (middle) at Muddy Branch Road
Site Description:	Erosion has end cut around a concrete weir (Figure 3-17). A logjam has formed between the new bank and the edge of the weir. Weir and logjam is located approximately 15m from an apartment building and presents a safety hazard.  Figure 3-17
Restoration Approach:	The logjam and weir should be removed to allow for adequate transport of both water and sediment through the stream channel at this location. Following removal of the weir, stable channel dimensions, patterns, and profiles should be reestablished through this section. The banks should be stabilized with native vegetation, and riprap if necessary.
Approximate Cost:	$15,000 - $30,000
Site No.:	GST-112
Site Score:	55.22
Location:	Great Seneca, tributary 1, near start of I-270 off ramp
Site Description:	Bank erosion has exposed sewer manhole and has undermined fence, eroding approximately ½ m of road embankment (3m wide) (Figure 3-18). The stream is now approximately 9m from edge of the road.  Figure 3-18
Restoration Approach:	Work with SHA to address eroded road bank issues at this location along I-270. At a minimum, the eroded road bank should be stabilized and the manhole should be protected from further lateral streambank erosion. This site could be stabilized by placing riprap around the exposed surfaces of the manhole to replace lost material and the eroded cut bank could be stabilized with vegetated riprap.
Approximate Cost:	$2,500 - $5,000

Site No.:	MB-104
Site Score:	55.00
Location:	Muddy Branch (lower), old breach in Lake Varuna at Lakelands Drive
Site Description:	A breach in the man-made berm of Lake Varuna caused by Hurricane Agnes in 1972 appeared to have been temporarily fixed with a log and plank wall covered with erosion control fabric (Figure 3-19). The channel has end cut around this temporary dam, eroding the berm and causing the dam to fail. The proximity of this site to the nearby residential community is a potential safety hazard. Restoration of this site also presents a good opportunity to provide additional flow control that can help to protect the downstream channel from further stormwater impacts.  Figure 3-19
Restoration Approach:	At a minimum, the dam structure should be removed from this location. The inner slopes of the berm at the breached location should also be stabilized with geogrid and vegetation to prevent further erosion and subsequent sediment deposition into the stream. The potential opportunity for a stormwater retrofit structure at this location should also be examined. For example, a new structure could be built at this location to provide both water quantity and water quality benefits.
Approximate Cost:	$2,500 - $35,000

3.3.2 Supplemental Sites for Restoration

Approaches have also been prepared for the following supplemental sites where the City may have additional opportunities to work with developers to improve current stream conditions.

Supplemental Stream Restoration Candidate Sites	
Casey-Metropolitan Grove Study Area	
Site No.:	GST-121
Site Score:	52.00
Location:	Great Seneca, tributary 1, at Metropolitan Grove Park
Site Description:	Riprap placed along the stream bottom and up a steep, 15-foot high bank to protect a sewer line crossing has been eroded at the toe of the riprap's leading edge. A bedrock outcrop located immediately downstream from the sewer line crossing provides some protection from downstream scour and channel incision.
Restoration Approach:	Place additional riprap around the toe of the slope and extend riprap along the outside bend several feet upstream. Care should be taken to maintain the channel dimensions, patterns, and profiles when additional riprap is placed along the bank and in the stream bottom..
Approximate Cost:	$1,500 - $2,500
Site No.:	CS-5
Site Score:	25.28
Location:	Great Seneca, tributary 1, near City boundary line
Site Description:	Originally chosen as a targeted stream-monitoring site, the stream has become over widened, has excessive bank erosion and bar formation, has become incised, and has poor riparian buffer along the south side of the stream. These channel adjustments are apparently a result of cumulative changes in hydrology driven by runoff from I-270 and land cover conversions from forest to meadow. Although impacts to the stream channel are significant, threats to public safety, property, and infrastructure are low. Future development slated for the large meadow along the southern side of the stream may necessitate raising the relatively low restoration priority of this site.
Restoration Approach:	To prevent further degradation of the stream at this location, forested riparian buffer (approximately 1,500 to 2,000 feet) should be planted along the southern side of the stream using native species of woody vegetation. The buffer should be protected through easements or other long-term conservation measures. In addition, development designs and construction activities should prevent concentrated flows from entering or passing through the buffer. Opportunities to control stormwater flows stemming from I-270, as well as from future development in the area, should also be examined, with a goal of maintaining or restoring a pre-development storm hydrograph. Future development in this area may also necessitate restoration of the stream's cross-sectional and plan-view profiles to provide adequate stability of the stream channel.
Approximate Cost:	$2,500 per acre conserved for acquisition of conservation easements, $9,000 per acre riparian reforestation; $15,000 - $25,000 to identify stormwater control opportunities; $400,000 - $750,000 for stream restoration

Casey-Goshen Tract/Hidden Creek Study Area	
Site No.:	GST-120
Site Score:	53.50
Location:	Whetstone Run, tributary 5, south of Mid-County Highway
Site Description:	Riprap placed in the stream to protect a sewer line crossing has caused downstream scour of the streambed and banks. The scour has undermined the riprap on the stream bottom and banks, causing the riprap to move, and decreasing its effectiveness in protecting the sewer line.
Restoration Approach:	To allow for adequate transport of both water and sediment through the stream channel at this sewer line crossing, riprap should be placed flush with the bed of the stream channel, with the finished crossing matching the dimensions of stable reaches located immediately above and below the crossing (i.e., same bankfull width/depth ratio, bankfull cross-sectional area, and slope).
Approximate Cost:	$10,000 – $25,000
Site No.:	GST-117
Site Score:	53.00
Location:	Whetstone Run, tributary 4, east of Goshen Road
Site Description:	An old roadbed crosses tributary 4 behind Forest Oak Middle School. A large willow tree (approximately 12” dbh) has grown near the upstream end of a culvert pipe beneath the roadbed, impeding water flow and sediment transport through the corrugated metal pipe. Large quantities of trash (e.g. foam cups, plastic bottles, plastic toys and other debris) have accumulated behind this blockage.
Restoration Approach:	At a minimum, the tree should be removed from in front of the culvert pipe, trash collected along this reach, and accumulated sediments removed to form a channel that has similar dimension, pattern, and profile to the un-impounded reaches above and below this blockage. If this road is not necessary, the roadbed and culvert should also be removed from both the stream channel and floodplain, and native vegetation could be re-established.
Approximate Cost:	$2,500 - $15,000
Site No.:	GST-118
Site Score:	51.50
Location:	Whetstone Run, tributary 5, south of Mid-County Highway
Site Description:	Riprap placed in the stream to protect a sewer line crossing has caused downstream scour of the streambed and banks. The scour has undermined the riprap on the stream bottom and banks, causing the riprap to move, and decreasing its effectiveness to protect the sewer line.
Restoration Approach:	To allow for adequate transport of both water and sediment through the stream channel at this sewer line crossing, reestablish stable channel dimensions, patterns, and profiles throughout the destabilized reach; vertical drops in the stream channel formed by headcutting processes could be stabilized by creating a step pool type channel morphology (using large rock to line the bottom of the step pools to diffuse energy); and stabilize banks by planting native vegetation.
Approximate Cost:	$15,000 – $30,000

Site No.:	GST-119
Site Score:	51.50
Location:	Whetstone Run, unnamed tributary entering tributary 5, south of Mid-County Highway
Site Description:	Riprap placed in the stream to protect a sewer line crossing has caused downstream scour of the streambed and banks. The scour has undermined the riprap on the stream bottom and banks, causing the riprap to move, and decreasing its ability to protect the sewer line.
Restoration Approach:	To allow for adequate transport of both water and sediment through the stream channel at this sewer line crossing, reestablish stable channel dimensions, patterns, and profiles throughout the destabilized reach; stabilize vertical drops in the stream channel formed by headcutting processes by creating a step pool type channel morphology (using large rock to line the bottom of the step pools to diffuse energy); and stabilize banks by planting native vegetation.
Approximate Cost:	\$15,000 – \$30,000
Site No.:	GST-116
Site Score:	46.67
Location:	Whetstone Run, unnamed tributary entering tributary 4, south of Girard Street
Site Description:	This meandering stream has 2-3m high, near-vertical banks that are within 15 m of a large apartment complex. A stormwater outfall located towards the top of this reach has become damaged by erosion. At this outfall, a concrete apron has collapsed, surface flows have endcut around the concrete headwall, and the ground above the headwall is subsiding. Footings for a concrete footbridge across this stream have also been dangerously undermined by streamflows.
Restoration Approach:	The slope of the stream's west bank is too steep in a number of places and should be laid back, and if necessary stabilized with geogrid, to provide a more stable slope. In addition, a riparian buffer containing a variety of native woody and herbaceous plants should be established along this section of stream. The outfall should be repaired and the bridge should be replaced, ensuring that stable channel dimensions are maintained. In addition, the bridge should be aligned perpendicular to the stream rather than cutting diagonally across the channel to prevent bank erosion problems similar to those observed.
Approximate Cost:	\$20,000 – \$40,000
Site No.:	GST-8
Site Score:	42.00
Location:	Whetstone Run, tributary 4, south of Victory Farm Road in Kelley Park
Site Description:	Originally chosen by random sampling as a stream-monitoring site, the stream lacks an adequate riparian buffer and has significant accumulation of trash and other debris. In addition, the stream appears to have been straightened, which can reduce the diversity of habitat available for aquatic organisms.
Restoration Approach:	A forested riparian buffer should be established along this stream using native species of vegetation. This buffer should also be protected through easements or other long-term conservation measures if located beyond park boundaries. Trash should also be collected from along the stream corridor to reduce possible water quality impacts and improve aesthetics.
Approximate Cost:	\$2,500 per acre conserved for acquisition of conservation easements, \$9,000 per acre riparian reforestation; nominal expense for volunteer trash clean up

Site No.:	GST-5
Site Score:	27.22
Location:	Whetstone Run, tributary 4, east of Goshen Road
Site Description:	Originally chosen by random sampling as a stream-monitoring site, only minor streambank erosion was observed at this site. The overall physical condition was considered good.
Restoration Approach:	The forested riparian buffer located along this stream should be protected through easements or other long-term conservation measures. Native species of woody vegetation could be planted to increase buffer width and increase plant community diversity. Development designs and construction activities should prevent concentrated flows from entering the buffer. The pre-development storm hydrograph should also be maintained throughout all phases of construction and occupation of the development.
Approximate Cost:	$2,500 per acre conserved for acquisition of conservation easements, $9,000 per acre riparian reforestation
Festival at Muddy Branch	
Site No.:	MB-3
Site Score:	31.89
Location:	Muddy Branch, tributary 3, east of Coral Reef Drive in Malcolm King Park
Site Description:	Originally chosen by random sampling as a stream-monitoring site, the stream has a significant accumulation of trash and other debris.
Restoration Approach:	Trash should be collected from along the stream corridor to reduce possible water quality impacts and improve aesthetics.
Approximate Cost:	Nominal expense for volunteer trash clean up
General Electric Tech Campus	
Site No.:	MB-102
Site Score:	53.28
Location:	Muddy Branch, tributary 1a (lower half), east of MD-28
Site Description:	Uncontrolled stormwater discharges from the General Electric facility, working in combination with the straightened upper half of the stream (see MB-6), have caused excessive streambank erosion and channel widening along most of the lower half of this tributary. New development east of this segment and in the stream's headwaters appears to have adequate SWM controls. Large gravel bars were evident in the low gradient portions of the channel between the pond outfall and MD-28. Above the pond outfall, the channel gradient increases, and an active headcut was observed along a 30m section of the stream as it parallels Edison Park Drive. The headcut portion of the stream has become incised approximately 2m. Although channel incision at this location was noted in 1996 (EQR), the headcut was not noted, indicating that it formed recently. The steeper gradient and faster flow velocities associated with channel straightening have played a major role in the formation of the headcut and downstream channel widening.
Restoration Approach:	Because restoration of the upper half of this tributary (MB-6) is integral to the successful restoration of the lower half of the tributary (MB-102), a combined approach for both halves has been provided here. To prevent further degradation of this stream, opportunities to control stormwater flows stemming from the General Electric facility should be examined and implemented, with a goal of maintaining or restoring a pre-development storm hydrograph. To repair the existing stream degradation problems, restoration efforts in the destabilized channel should include recreation of the entire stream channel (approximately

	2,000 feet) using nearby reference reaches as a template for designing stable channel dimensions, patterns, and profiles, and stabilizing the banks with native vegetation. Vertical drops in the stream channel formed by headcutting processes can be stabilized by creating a step pool type channel morphology (using large rock to line the bottom of the step pools to diffuse energy); grade control structures should also be installed to prevent further incision of the channel
Approximate Cost:	$100,000 – $250,000 for assessment and construction of stormwater retrofits; $250,000 – $600,000 for stream restoration
Site No.:	MB-6
Site Score:	42.78
Location:	Muddy Branch, tributary 1a (upper half), east of MD-28
Site Description:	The upper half of this tributary appears to have been channelized some time ago, resulting in a very straight, uniform channel approximately 0.45m wide and 0.3m deep. The channel receives parking lot runoff directly from the General Electric facility via underground pipes. No flow controls were apparent.
Restoration Approach:	Because restoration of the upper half of this tributary (MB-6) is integral to the successful restoration of the lower half of the tributary (MB-102), a combined approach for both sites has been included above for MB-102.
Approximate Cost:	Included in MB-102
Lakelands Development	
Site No.:	MB-103
Site Score:	33.06
Location:	Muddy Branch (lower), from near Still Creek Lane down to MD Route 28 bridge
Site Description:	At this location, the channel is approximately 40 feet wide, has large, side and mid-channel gravel bars, shows signs lateral channel migration, and has 6-8 foot high, near vertical banks. Runoff from a SWM outfall near Alderwood Drive has split into multiple channels in the woods adjacent to the stream; these intermittent channels have headcut and incised to match water levels in Muddy Branch. The mainstem of Muddy Branch in this reach is experiencing on-going planform, slope, and cross-sectional channel adjustments in response to upstream disturbance. Although not immediately threatened by these adjustments, a sewer line paralleling the south side of Muddy Branch and the channel alignment through the MD Route 28 bridge (currently undergoing re-construction) may be threatened in the future.
Restoration Approach:	The multiple drainage pathways below the SWM outfall should be protected from further incision and headcutting by consolidation into a single channel that has a stable channel dimension, pattern, and profile. Vertical drops in the drainage channel formed by headcutting and incision processes could be stabilized by creating a step pool type channel morphology (using large rock to line the bottom of the step pools to diffuse energy). To protect the eroding stream banks, especially near the sewer line and near the approach to the bridge, the slope of the stream banks should be laid back, and if necessary stabilized with vegetated geogrid or vegetated riprap, to provide a more stable slope. Shade tolerant grasses and shrubs should be planted along the stream to help stabilize stream banks, filter runoff, and increase the diversity of vegetation within the existing forested riparian buffer. If not already protected, the buffer should be protected through easements or other long-term conservation measures. In addition, future development designs and construction activities should prevent concentrated flows from entering or passing through the buffer.

Approximate Cost:	$10,000 – $15,000 to stabilize drainage pathway; $150,000 – $200,000 for bank stabilization; $2,500 per acre conserved for acquisition of conservation easements, $9,000 per acre riparian reforestation
Site No.:	MB-5
Site Score:	28.61
Location:	Muddy Branch (lower), near Turtle Pond Lane
Site Description:	Originally chosen by random sampling as a stream-monitoring site, this site as well as the rest of Lower Muddy Branch has been subject to the cumulative impacts of upstream development and stormwater runoff. Channel adjustments driven by the resulting hydrologic changes observed in this part of Muddy Branch include shallow and over-widened channels, excessive bar formation that frequently shift location, rapid bank erosion, lateral channel migration, and near vertical banks. Although impacts to the stream channel are significant, threats to public safety, property, and infrastructure are low.
Restoration Approach:	To prevent further degradation of the stream at this location, the existing forested riparian buffer should be supplemented by planting native species of shade tolerant grasses and shrubs along the stream. If not already protected, the buffer should be protected through easements or other long-term conservation measures. In addition, future development designs and construction activities should prevent concentrated flows from entering or passing through the buffer.
Approximate Cost:	$2,500 per acre conserved for acquisition of conservation easements, $9,000 per acre riparian reforestation
Site No.:	MB-2
Site Score:	26.39
Location:	Muddy Branch (lower), near Gentlewood Street
Site Description:	Originally chosen by random sampling as a stream monitoring site, only moderate streambank erosion and a small break in the riparian buffer were observed at this site. Approximately 100 feet of the existing forested riparian buffer had been cleared on the north side of the stream for the construction of a footpath and SWM facility outfall for the Lakelands development. The minor bank erosion problems noted in fall 2001were stabilized with riprap in the following months. Therefore bank stability has been improved.
Restoration Approach:	To repair the break in the forested riparian buffer, native species of woody vegetation should be planted in the grassy area between the footpath and the stream. If not already protected, the buffer should be protected through easements or other long-term conservation measures. In addition, development designs and construction activities should prevent concentrated flows from entering or passing through the buffer.
Approximate Cost:	$2,500 per acre conserved for acquisition of conservation easements, $9,000 per acre riparian reforestation

4.0 CITIZEN STREAM MONITORING SITES

The City of Gaithersburg can benefit greatly from involving citizens in volunteer stream monitoring and restoration efforts. Many successful watershed programs have proven that citizen involvement can have measurable, positive effects on water quality and watershed health (Isaak Walton League 2002). Volunteers or students can collect key data to supplement the information collected by state and local agencies (USEPA 1998). Citizen data can be used to assess additional stream locations and to screen for potential problems that might otherwise go undetected. In addition, hands-on participation in stream monitoring helps to educate citizens about their local streams and encourages environmental stewardship. Participants who start with an interest in monitoring often get involved in other projects such as neighborhood stream clean-ups, tree plantings, and stream restoration.

There are a number of regional programs that can serve as useful models as the City develops its citizen monitoring efforts. The City may want to coordinate with one or more of these successful programs, which include the following examples.

- **Maryland Stream Waders** is a volunteer stream sampling program sponsored by DNR that began in February 2000. The goals of this program are to increase the density of sampling sites for use in stream quality assessments; to educate local communities about the relationship between land use and stream quality; to provide quality-assured information on stream quality to state, local, and federal agencies, environmental organizations, and others; and to improve stream stewardship ethics and encourage local action to improve watershed management (MDNR 2002). Each year, volunteers participate in a one-day training session and then spend about two days during springtime collecting aquatic invertebrate samples from local streams. The samples are sent to DNR for identification and analysis. Local governments can participate by helping to identify targeted sites for sampling. In the program's two years, Stream Waders sampled more than 700 sites in Maryland.
- **Save Our Streams (SOS)** is a national watershed education and outreach program of the Isaak Walton League, headquartered in Gaithersburg (Isaak Walton League 2002). For more than 30 years, SOS has developed programs to educate and motivate citizens to clean-up stream corridors, monitor stream health, restore degraded stream banks and protect wetlands. SOS has been active in communities nationwide through the League's local chapters. SOS promotes biological and chemical monitoring by volunteers and encourages the use of volunteer data in environmental decision-making. At its Gaithersburg property, the League implemented the Muddy Branch Stream Restoration Project, including design and installation of streambank stabilization using bioengineering techniques; preparation of a master plan for restoration; and public education involving local partners.
- **Montgomery County Stream Teams** is a partnership of Montgomery County DEP, public and private schools, and community groups to promote adoption and

stewardship of local streams (Montgomery County DEP 2002a). Interested leaders attend training workshops and coordinate with DEP to select stream sites and plan related activities. Participants adopt local stream segments; conduct biological and stream habitat monitoring; perform restoration activities such as stream clean-ups, tree planting, or stormdrain stenciling; and report problems such as illegal discharges, trash dumps, fish kills, and erosion. Stream Teams are invited to participate in watershed conferences and public meetings, and help deliver important messages about local stream quality to the County Executive and County Council.

- **Montgomery County Pipe Detectives** is a program where volunteers walk along designated neighborhood streams to observe and report to County officials any suspect discharges coming from stormwater pipes and channels flowing into streams (Montgomery County DEP 2002b). Pipe Detective volunteers serve as "environmental watchdogs", reporting illicit discharge violations (such as dumping of motor oil or anti-freeze) to the County. Training is provided by Montgomery County DEP staff. The program's goal is to actively involve County residents in preventing pollution, while fostering a sense of stewardship through hands-on participation.

The City of Gaithersburg is interested in identifying potential stream monitoring locations that could be incorporated into a citizen stream monitoring program. In such a program, stream sites would be monitored by volunteers, who, with the appropriate training, would most likely sample for benthos and cursory habitat information. To locate appropriate monitoring sites, candidate locations were first identified in the field during the extensive stream surveys discussed in Sections 2 and 3 of this report. These candidate monitoring sites were identified between November 2001 to June 2002, and were evaluated using the following criteria:

- Parking - parking lots or spaces were preferable;
- Land ownership - community- or city-owned land was preferable. It must be noted that the land ownership list in the following table is not definitive and should be reviewed further before initiating a monitoring program at any site;
- Accessibility - short, direct walks with no impedances were preferable;
- Wadeability - stream must not be too deep for access; and
- Slope of bank - related to accessibility and safety concerns, bank must not be too steep.

Based on the above criteria, the following 18 potential citizen stream monitoring sites were identified by field personnel (Table 4-1). A map of these sites (Figure 4-1) is also included to show their locations within the City. Site numbers indicate the origin of the site. For example, some sites (e.g., CS 3, GST 2) are the same locations assessed in the 2001-2002 stream assessment (see Section 2 of this report). Others (e.g., GST 101, MB 104) correspond to potential stream restoration sites (see Section 3). A few sites (CM 1 to CM 3) were specifically identified as good locations for citizen monitoring based on general field reconnaissance or recommendations from the City.

Table 4-1. Potential citizen stream monitoring sites

Site	Parking	Land Ownership	Accessibility	Wadeability	Slope of Bank
Muddy Branch					
MB 1	Parking lot on Timberbrook Lane	Community Land	Bike Trail from parking lot	Okay	Okay
MB 10	Parking lot at Morris Park	Community Land	Easy access from park	Okay	Okay
MB 104	Along Lakelands Drive	Community Land	Walk downstream past old berm for Lake Veruna	Okay	Okay
MB 105	Parking for Summer Walk Drive	Community Land	Walk 1/4 mile downstream, cross drive	Okay	Okay
Great Seneca Tributary					
CM 3	Malcolm King Park	City Land	Walk from park	Okay	Okay
CM 1	Parking lot for Washingtonian Woods Park	Community/ City Land	Walk behind tennis courts	Okay	Okay
GST 2	Townhomes on Knoll Mist Lane	Community Land	Path from townhomes	Okay	Somewhat steep
GST 5	Forest Oaks Middle School Parking Lot	Community Land/school	1/4 mile walk from middle school	Okay	Okay
GST 8	Parking lot at Kelley Park	Community/ City land	Direct access from park	Okay	Somewhat steep
CS 3	Rabbitt Road at stream crossing	Community Land	Off of Rabbitt Road	Okay	Okay
CS 6	Hunt Club Apartments parking lot	Community Land	Walk from apartments	Okay	Okay
GST 101	Diamond Elementary School parking lot	Community Land/school	Footpath from school	Okay	Okay
GST 102	End of Diamond Drive	Community Land	Path from road	Okay	Okay
GST 106	Behind apartment complex	Community Land	Walk from apartments	Okay	Okay
GST 110	Brown Site Elementary School	Community Land/school	Walk from school	Okay	Okay
GST 113	Townhomes on Travis View Court	Community Land	Walk from townhomes	Okay in lower reaches	Okay
GST 116	Apartments north of Girard Avenue	Community Land	Walk from apartments	Okay	Okay
CM 2	Parking lot for Forest Oaks Middle School	Community Land/school	Walk from school - already an outdoor classroom set up	Okay	Okay

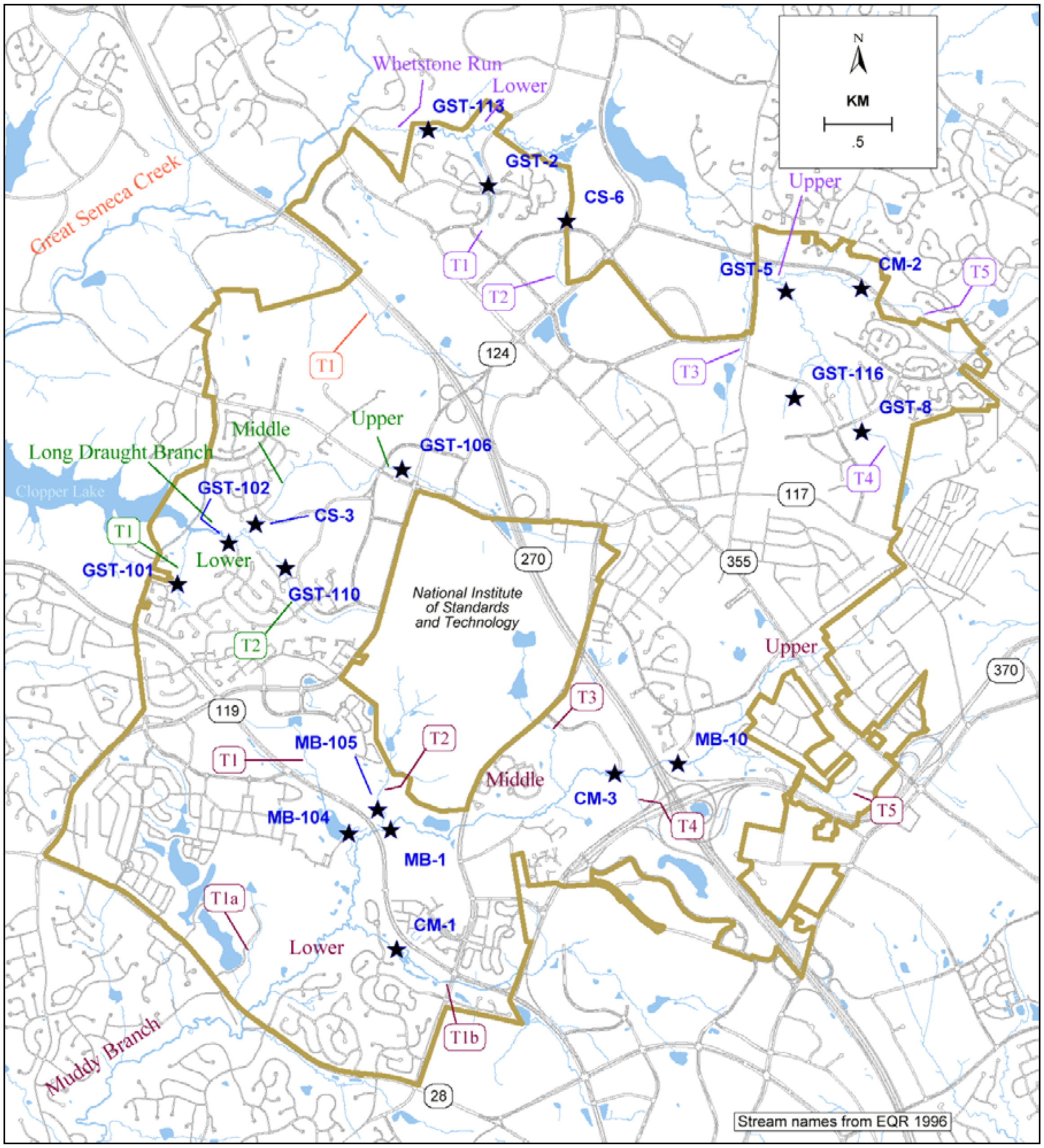


Figure 4-1. Potential citizen stream monitoring sites in the City of Gaithersburg

5.0 SUMMARY AND RECOMMENDATIONS

The individual components of this study are intended to collectively provide information to the City of Gaithersburg to help in managing its freshwater streams. The following sections include an integrated summary of the three major components (assessment of stream conditions, identification of stream restoration opportunities, and identification of potential citizen stream monitoring locations), followed by recommendations to improve stream physical and water quality conditions within the City.

5.1 INTEGRATION OF STUDY FINDINGS

Monitoring of instream physical habitat, biology, and water chemistry took place between December 2001 and June 2002, and coincided with surveys to identify potential stream restoration opportunities and citizen monitoring locations. Urban streams often show significant signs of channel instabilities, altered hydrology, degraded biological habitat, low biological diversity, and poor water quality; many of these symptoms were evident in Gaithersburg's streams.

The stream assessment, in which a final nine randomly selected and seven targeted sites were monitored in the Muddy Branch and Great Seneca Tributary watersheds, indicated that physical habitat impacts and channel instabilities were severe and widespread. Benthic macroinvertebrate and fish assemblages were relatively poor when compared to reference conditions for Piedmont streams in Maryland. However, biological conditions in Gaithersburg streams were comparable in many ways to similarly urbanized sites in surrounding Montgomery County. Results for conductivity and pH indicated poor water quality conditions at many of these urban streams.

Fifty-two candidate restoration sites were identified in the field surveys. Based upon a semi-quantitative analysis of field data, in conjunction with several key decision criteria, sites were ranked to determine which represented the best opportunities for restoration. Descriptions of problems and recommend restoration approaches were prepared for the ten sites considered to have the best restoration potential, as well as for twelve other sites in which the City may have additional opportunities to work with developers to improve current stream conditions. Eighteen potential citizen monitoring sites were identified within the City, based on a number of access, safety, and sampleability considerations.

5.2 RECOMMENDATIONS

As described earlier, problems affecting water quality in the City's watersheds arise predominantly from historic stormwater management practices. Taken individually, many of the watershed problems might have little detrimental effect; however, the cumulative effect throughout a watershed is moderate to severe. General problem types evident in the City's streams include alteration of natural flow regimes, erosion and channel destabilization, sediment deposition, nonpoint source (and possible point source) pollution, and physical habitat degradation. In many cases, problems are most severe where the unrestricted discharge of large volumes of stormwater collected over large areas has destabilized the receiving stream channel.

There are a number of opportunities available to the City of Gaithersburg to protect and improve its valuable water resources. Specific recommendations, described below, include general programmatic approaches as well as site-specific opportunities. These actions address the primary threats to water quality, including stormwater runoff from existing development, managing stormwater in future construction and development, and restoring instream habitat.

5.2.1 Stormwater Management

Historical land development and stormwater management practices in Gaithersburg, as in many cities of similar size and setting, have influenced many of the issues noted in this assessment. There are a number of tools the City may apply to both existing and future development to avoid, minimize, and mitigate the impact of stormwater runoff.

Watershed Assessment and Planning: Stream research generally indicates that stream quality declines dramatically when the extent of impervious surface exceeds certain thresholds (CWP 1998). Specifically, at about 10 percent impervious cover, sensitive stream elements are lost from the riverine system; at around 25 to 35 percent impervious cover, most indicators of stream quality consistently shift to a poor condition. Many sections of Gaithersburg likely exceed these impervious thresholds, so it is not surprising that stream degradation is common here. Still, land use planning can be an important tool for watershed management. Within individual developments, reductions of impervious surface area can reduce stormwater runoff volumes and peak discharges. Also, on a broader scale, identifying those remaining areas of the City with low impervious surface could be useful in targeting lands for preservation.

It is recommended that the City initiate a formal watershed assessment process to examine current and future land use patterns from a watershed perspective. An assessment of this nature can be used to establish a baseline of current conditions that will help resource managers understand land use pressures on streams, identify sensitive areas, and develop special protections for these sensitive areas. Biological monitoring data from this stream assessment will provide critical input into such a watershed assessment and help identify sensitive areas. Modeling of hydrologic patterns and pollutant loads would be employed to assess the effectiveness of current stormwater management facilities and to help identify potential retrofit opportunities. Land use characterizations and model results would be incorporated with the present evaluations of biological and physical habitat conditions. Together, information would provide a better understanding of the stressors and environmental responses taking place within specific subwatersheds and stream reaches.

Outcomes of the planning process would include identification of critical areas for land conservation, development of management restrictions for specific sensitive areas (see Special Protection Areas below), targeting stormwater retrofits (see below) and perhaps further recommendations for stream restoration. In addition, watershed planning would involve education and outreach efforts.

Creation of Special Protection Areas: Another recommendation for improving stormwater management and protecting natural resources is the creation of special protection areas. Under this approach, areas with high quality streams or other sensitive natural resources are designated for special environmental protection measures. Under Montgomery County's Special Protection Area (SPA) program (Montgomery County 2001), County agencies and the Maryland-National Capital Park and Planning Commission (M-NCPPC) work pro-actively with developers to minimize impacts to these designated areas. SPA requirements address site layout, environmental buffers, forest conservation, site imperviousness, stormwater management, and sediment control measures.

Coordination begins early in the development review process. For proposed projects within SPAs, Montgomery County and M-NCPPC staff provide environmental information and guidance on enhanced protection measures to the applicant prior to the concept plan design stage, before the formal development review process begins. Applicants are then able to design projects that address environmental concerns and objectives. Most applicants are required to prepare water quality plans that detail how the project will meet site-specific watershed protection goals. Input from the public is solicited through public information meetings and hearings.

Within SPAs, the County conducts stream monitoring to evaluate baseline conditions and to monitor for development impacts. Physical habitat, fish, and benthic macroinvertebrate assessments provide critical information to evaluate whether high quality systems are being maintained. Also, a number of development projects in SPAs are required to monitor the effectiveness of Best Management Practices (BMPs) in managing stormwater and protecting water quality. Montgomery County (2001) reports that preliminary benefits of the SPA program include progress in protecting undisturbed natural areas as environmental buffers, minimizing impervious surface areas in new developments, documenting BMP effectiveness, and improving models of development impacts to stream conditions by considering mitigation by BMPs.

Inventory and Inspection of Existing Stormwater Management Structures: As one of the first steps to improve stormwater management and to identify potential retrofit opportunities, the City should develop an inventory of the existing stormwater management structures and inspect their condition. In many cases, older structures do not provide the protection they were originally intended to provide. Often, water quality and quantity control functions are reduced over time because of sedimentation or other inadequate upkeep of structures. However, with proper maintenance and, in some cases, minor adjustments, many existing structures could help reduce pollutant and flow impacts to streams. This approach could provide significant stream improvement benefits for a relatively low cost. In particular, benefits would be targeted to degraded streams, because existing structures are located within established developments where better water quality and quantity treatment is needed.

In fact, ensuring adequate, long-term operation and maintenance of stormwater controls would support one of EPA's minimum control measures for municipalities regulated under NPDES Phase II stormwater regulations. A database or GIS-based inventory of existing stormwater management structures would provide geographic coordinates, identify facility locations in relation to the City's stormdrain network, and provide names and contact information for owners responsible for facility maintenance. City personnel would seek to inspect all facilities, identifying regular maintenance needed at each site as well as potential modifications to improve water quality or quantity control. The inventory database would be useful in scheduling inspection visits and tracking follow-up actions. In working with facility owners, the City could even consider making some funds available to homeowners' associations or other owners who do not have sufficient resources to undertake needed repairs or improvements.

Stormwater Retrofit Assessments: Stormwater best management practices are needed to compensate for the changes to watershed hydrology caused by new or existing development. Stormwater hydrology and its effects on stream geometry are a complex issue best addressed at each site early in the project site planning and design phase; however, opportunities often exist to address these issues retroactively in areas already developed without such controls. In either case, stormwater control goals generally fall into the following categories: (1) maintain ground-water recharge and quality, (2) reduce stormwater pollutant loads, (3) protect stream channels, (4) prevent increased overbank flooding, and (5) safely convey extreme floods.

It is recommended that the City identify and prioritize opportunities for structural storm-water BMPs to better manage urban stormwater through implementation of a stormwater retrofit feasibility analysis. Opportunities may involve retrofits of existing SWM facilities and imperv-ious surfaces, and establishing new City-owned or privately owned facilities in uncontrolled areas. This analysis should examine opportunities to reduce stormwater runoff volumes and velocities and provide water quality treatment at a variety of scales, from the individual lot size (e.g., open curbs, infiltration trenches, bioretention, rain barrels, SWM ponds, porous pavement) up to a regional scale (regional SWM facilities, stormdrain cleanouts, street sweeping, inlet protection).

Montgomery County has pursued an extensive program of watershed restoration studies in its most heavily developed watersheds. Objectives of these studies are to identify impaired stream reaches, locate retrofit and restoration opportunities, evaluate project feasibility and benefits, and to help set priorities for project implementation (Montgomery County 2000). Stormwater management projects identified and implemented through this process have included both new facilities and retrofits of existing structures. To date, eight stormwater projects have been completed or are under construction; an additional 18 projects are underway or in design (Montgomery County 2002).

One example of a watershed restoration feasibility study is summarized in the County's recently completed restoration action plan for Rock Creek Watershed (CWP 2001). This study identified 48 candidate stormwater management project sites and used multiple criteria (e.g., pollutant load reduction, cost, feasibility, and environmental benefits) to rank sites. Watershed factors such as erosion extent and amount of public support were considered in the final selection of 11 priority projects, including stormwater pond retrofits, new ponds, stormwater wetlands, and sand filters.

Montgomery County plans to begin a Watershed Restoration Study in Great Seneca Creek during FY04 (Montgomery County 2002). The City of Gaithersburg is encouraged to participate in this watershed-wide effort, particularly to help identify restoration strategies for the Great Seneca Creek tributaries that are within the City.

Over the past ten years, the City of Rockville has pursued numerous stormwater retrofit projects to address urban stream problems (Lise Soukup, City of Rockville, personal communication). Among recent successes is the Hungerford-Stoneridge Marsh, a three-acre wetland that provides treatment and stormwater management for runoff from 450 acres of downtown Rockville. Because the project incorporated natural design features, it has been well-accepted by local residents. Another example is the Tower Oaks Marsh, a wet pond with wetland fringe that serves as a regional stormwater pond for several developments and a portion of I-270. The City has found that in some cases, large projects offer greater opportunity to develop desirable features, because flows are sufficient to support vegetation. The City of Rockville has also undertaken a number of stream restoration projects employing channel stabilization techniques such as bioengineering, imbricated riprap, and rock vane structures.

Rockville has recently completed an assessment of Watts Branch Watershed to identify stream restoration and stormwater management solutions. A critical component was public involvement in the planning process. The City worked with local residents and used a list of key criteria (including both technical factors and community concerns) to prioritize among 54 candidate stormwater projects. This list was narrowed to 18 candidates, from which a final 14 projects were selected for implementation.

The City of Rockville has found that in many cases, the best opportunities are retrofits of older facilities that can be upgraded to meet current stormwater management standards. A retrofit may be as simple as changing the configuration of a riser or orifice opening. Not only are these fixes relatively inexpensive, but it is often easier to gain public acceptance for improving an existing structure, compared with developing an new facility where none previously existed.

Stream Valley Buffers: Vegetated buffers along stream corridors deserve special attention because of their functional importance in watershed protection. The primary benefit of buffer areas is to physically protect and separate a stream or wetland from future disturbance or encroachment. Buffers can also remove pollutants traveling in stormwater or groundwater, although in more urban settings concentrated runoff and storm drain systems can effectively by-pass buffers and limit their benefit (CWP 1998). Buffers can also provide substantial wildlife and recreation benefits if managed as forest.

In accordance with the goals of the Forest Buffer Initiative under the Chesapeake Bay Program, and its own requirements, the City should continue to strictly enforce its 100-150 foot setback requirements. The City is strongly encouraged to continue and build upon its current efforts to restore forested stream valley buffers. In addition, the City should evaluate whether their staff has the authority to inspect buffers for activities that may reduce their effectiveness both during and after site development, and then enforce corrections should they be necessary. If the City does not have this authority, then efforts should be made to gain this inspection and enforcement ability. These actions will have benefits beyond stream quality that include support of wildlife and recreational activities.

Utilize Low Impact Development/Innovative Site Designs: Low impact development (LID) approaches, such as those developed by Prince George's County, Maryland (1999), offer innovative solutions that can prevent or reduce stormwater-related and other adverse environmental impacts resulting from development. The principal goal of low impact development is to protect of stream integrity by maintaining the watershed's hydrologic regime. The challenge is to make a developed area function hydrologically like a natural system both at the lot level and development-wide scales. The idea is to maintain watershed integrity by maintaining (or restoring) natural, pre-development hydrology on each development site, so that the overall landscape functions more effectively to mimic natural flow. Practices are targeted to reducing stormwater runoff at the source, not merely in managing flows as they leave a site, thus having a significant positive effect on stream stability, habitat structure, base flows, and water quality.

Examples of LID practices include:

- *Conserve naturally vegetated areas*. Not only is it critical to maintain an adequate riparian buffer (e.g., with a dense and diverse mix of native herbaceous and woody vegetation, wider is better), but also to preserve as much overall watershed forest/vegetation cover as possible, to provide for rainfall interception, water uptake by plants, and reduce runoff.

- *Minimize development impacts*. Configure development layouts to reduce impervious surfaces, cluster buildings and reduce building footprints, reduce road and driveway widths, utilize porous pavement for overflow parking, preserve sensitive soils and those with higher infiltration rates, and seek alternatives to the direct transport of stormwater through storm pipes, curbs, and gutters. During construction, minimize disturbance and grading, both in time and area, to limit bare soil exposure and minimize impacts to existing vegetation.

- *Maintain site runoff rate*. Where practical, use open drainage (e.g., grassy swales instead of enclosed pipes), maintain natural flow paths, disperse rather than concentration drainage, lengthen flow paths, and maximize sheet flow. Directing flow to properly designed vegetated or bioretention areas will allow increased infiltration.

- *Use integrated management practices (IMPs), where applicable*. In some cases, small-scale SWM controls distributed throughout site can prove more effective than larger ponds. Controls should be designed to maintain flow patterns, filter pollutants, and re-create or maintain natural hydrology. Employ practices such as disconnectivity (e.g., diverting roof or parking lot drains to rain barrels or vegetated areas), bioretention, open swales, permeable/porous pavement, sand filters, and inlet retrofits.

- *Implement pollution prevention, proper maintenance, and public education programs*. Particularly with an influx of many new residents, individual actions that reduce runoff (e.g., rain gardens) and improve water quality (e.g., proper use of fertilizers and pesticides) can together have a substantial impact. Public education programs can help instruct property owners on appropriate maintenance practices that will promote the long-term function of each IMP. In addition, the City should ensure that it has adequate enforcement measures (e.g., easements, maintenance agreements) in place to address problems as they arise.

Designing individual development projects to reduce the amount of impervious surface they create is a new, but potentially powerful, tool for watershed protection. Innovative site design can employ one or more strategies, such as (1) open space or cluster housing, (2) green parking lots, (3) narrower streets near headwater streams, and (4) directing rooftop runoff onto pervious surfaces. Open space or cluster development can reduce the amount of impervious surface by 10 to 50 percent, and often reduces development costs (CWP 1998). Green parking lots and "headwater" streets involve revising current codes on the number and size of impervious surfaces needed to meet transportation needs, as well as modifying designs to route runoff to pervious surfaces. Permeable materials, such as geosynthetics, may also be used for infrequently used parking and driving surfaces. Routing rooftop runoff to grassy areas or stormwater control features can reduce annual runoff volumes in medium- to low-density residential land uses by 50 percent (Pitt 1987).

The City should evaluate these approaches and techniques and apply them to the greatest extent practicable during the planning and review of new construction projects as well as retrofitting existing residential, commercial, and public properties.

Use Redevelopment to Upgrade SWM Controls: Redevelopment activity presents a unique opportunity to upgrade SWM protections in older areas of the City that do not have adequate controls. Although redevelopment does not wipe the slate clean, it provides a chance to implement a wide range of controls outlined above in the stormwater retrofit and LID recommendations.

Address Illicit Discharges to the Storm Sewer System: The City should continue its efforts to eliminate illicit discharges to the storm sewer system. Illicit discharges are unpermitted discharges that can bring substantial pollution directly to streams. Examples include sewage (which may enter the storm sewer system through older pipes or connections), gray water discharges such as household laundry/wash water, motor oils poured down drains or into ditches, and unpermitted industrial discharges. The City should increase its inspection and enforcement programs to reduce and eliminate illicit discharges. To aid in this effort, a database of locations for the City's 500+ stormwater outfalls will soon be available. In addition, the City should encourage citizen involvement in detecting illicit discharges and should establish a mechanism by which citizens can report problems to the City.

Road Maintenance Activities: Roads present a major source of nonpoint pollution to urban streams as particulates, sediment, trash, and debris are washed from paved surfaces into streams, often via stormdrains. The City is encouraged to maintain a regular and frequent street sweeping and stormdrain clean out program, which will intercept pollutants before they are transported into the City's streams. The City currently employs a vacuum sweeper and is considering expansion of the current sweeping program. Similar activities should be encouraged along roads not maintained by the City.

Review Erosion and Sediment Control Standards: The relatively short period when vegetation is cleared and the site graded prior to construction poses particularly severe threats to receiving waters. Well-enforced clearing restrictions, coupled with erosion and sediment controls, are needed to protect streams during this period. Because of the severity of this threat, it is recommended that the City reassess structural and non-structural erosion and sedimentation control requirements, plan review process and minimum acceptable standards, and inspection procedures to determine if current practices are effectively protecting water quality and habitat in the City's streams.

5.2.2 Stream Restoration

Flooding, excessive erosion and sediment deposition, and poor physical habitat are common problems associated with destabilized stream channels. Stream corridor restoration is a valuable tool that can help return impacted streams to a more stable and functional condition, and thereby prevent additional degradation of water quality, habitat, and biological resources. The assessment and prioritization of candidate stream restoration opportunities (see Section 3 of this report) is a major step towards improving the City's streams.

It is recommended that the City examine the ten sites recommended for restoration and develop a strategy and schedule for obtaining funding, the necessary regulatory permissions, developing the conceptual restoration approaches into specific plans, and then implementing projects. Where possible, stream restoration should be implemented in conjunction with stormwater management improvements, as outlined above. In addition, the City should pursue cooperative efforts with local developers to implement restoration projects at the additional 15 sites linked to specific proposed developments. It should be noted that alternate stream restoration projects could be implemented if the City's restoration priorities change or other opportunities arise.

5.2.3 Citizen Involvement

Citizen involvement is an integral component of water resource management. By involving citizens, the City can not only stretch limited resources by using volunteers to help on specific projects, but also provide educational opportunities and build stakeholder buy-in to City management efforts and goals. To solicit citizen involvement, the City could tap into the existing network of active citizens and programs in the area by contacting existing organizations (e.g., Maryland DNR Stream Waders, Isaac Walton League Save Our Streams, Montgomery County Stream Teams, Chesapeake Bay Foundation), or organize citizens directly by publicizing and coordinating its own events. The following opportunities for incorporating citizen help are recommended.

Selection and Implementation of Stormwater Management and Stream Restoration Projects: As noted by the City of Rockville (Lise Soukup, personal communication), citizen participation is often critical to the success of stormwater retrofit and restoration projects. Projects can involve citizens throughout the watershed study process, both to inform residents of study findings and also to solicit input for selecting potential stormwater management and stream restoration projects for implementation.

Pollution Detection: With minimal training and materials, volunteer monitors can be utilized to observe and report on stream conditions. For example, the Montgomery County DEP has a Pipe Detectives program in which residents who want to help improve local water quality assist in locating and identifying sources of pollution entering streams in specified watersheds throughout the county. In similar programs elsewhere, Mud Busters report on erosion and sediment problems stemming from construction sites.

Stream Adoption: Similar to road adoption programs, citizens can adopt portions of a stream and volunteer their time to clean up trash, stencil stormdrains, perform basic water quality, physical, and biological monitoring, as well as a wide range of other activities. The potential citizen monitoring sites in Section 4 of this report represent opportunities for involving various school and community groups in stream monitoring and adoption.

Restoration Activities: Citizen participation may also be a valuable component to restoration projects undertaken by the City. Guided by knowledgeable supervisors, volunteers can assist stream restoration and riparian buffer planting projects in a number of ways, including construction of habitat structures, installing bank protection, planting trees and other types of vegetation, and monitoring post-construction conditions.

5.2.4 Long-term Monitoring

Because stream conditions change over time, especially with ongoing efforts to improve conditions, it is important that the City establish a long-term stream monitoring program to evaluate trends in stream condition, document improvements, target future control efforts, and gain a better understanding of the status of the City's natural resources. Stream monitoring efforts conducted in this study can serve as a baseline, or starting point, against which the efficacy of future efforts to control non-point source pollution can be measured. As BMPs are implemented, continued monitoring will provide data that, over the long term, can be compared to this baseline and other historical information. Any significant reduction in pollutants (i.e., improved water quality) provided by the new BMPs should be evident in the monitoring data. Additionally, a process of adaptive management (based on the long-term monitoring), refinement of existing BMPs, and the introduction of additional BMPs and source controls, should effectively reduce non-point source pollution and its impact on the City's streams.

To facilitate comparison of data from various stream monitoring studies, locations, and scientists, it is strongly recommended that uniform field, laboratory, and data analysis methods be used. This baseline survey relied upon stream monitoring methods employed by the MBSS and Montgomery County DEP. These methods proved to be effective and their continued use is recommended for future stream monitoring efforts. In particular, the following long-term monitoring elements are recommended.

Existing Targeted Locations: Because construction activities can result in severe, though typically short-term, impacts to nearby streams, it is recommended that targeted stream monitoring sites be re-assessed annually during active phases of construction. Following the completion of construction activities, it is recommended that stream monitoring be performed regularly every three to five years to monitor future conditions. The need for continued long-term monitoring should be re-evaluated on a site-by-site basis every ten years.

Randomly Selected Locations: The incorporation of randomly selected monitoring locations in the baseline stream survey allowed inferences on City-wide stream conditions to be drawn from relatively few sites. These data provided a valuable snapshot of current conditions, therefore, it is recommended that monitoring of 10 randomly selected stream locations be conducted regularly every three to five years to monitor future conditions. The need for continued random long-term monitoring should be re-evaluated every ten years.

New Development: New development and re-development projects begin frequently within the City and their potential impacts to streams should be monitored. The City should establish a mechanism by which streams adjacent to these projects are added to the targeted monitoring program.

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APPENDIX A

STREAM ASSESSMENT FIELD DATA SHEETS

Gaithersburg Fall Cross Section Sheet

Cross Section: Measure from the Left bank looking downstream.

Station: ______________ Date: ________________

X-section located at___________m

Tape Distance (m)	Height distance to bank/ bottom (ft)	Water Depth (m)	Velocity (cms)	Notes
BM1				
BM2				
BM1 (QC)				
0				

Benchmark Location: ___________________________

____

____

____

____

____

Slope:

Downstream		Upstream	
Angle	______	Angle	______
Top sight	______	Top sight	______
Middle sight	______	Middle sight	______
Bottom sight	______	Bottom sight	______

Instrument Height___________m

Bank Pin Location: ___________________________

____

____

____

____

To be done at a riffle close to the cross section (Record location of the riffle):

Physical Water Quality Information:

Parameters	@ The Cross Section
Air Temperature	
Water Temperature	
Dissolved Oxygen	
pH	
Conductivity	
Turbidity	

	Left Side of Riffle	Center of Riffle	Right Side of Riffle	Avg
1. % Embeddedness				

PEBBLE COUNT

Site: Reach: Date:

PEBBLE COUNT Reach: Date:

PEBBLE COUNT Reach: Date:

	PARTICLE	Millimeters		PARTICLE COUNT 1	2	3	TOT #	ITEM %	% CUM	TOT #	ITEM %	% CUM	TOT #	ITEM %	% CUM
	Silt / Clay	< .062	SILT/CLAY												
	Very Fine	.062 - .125	SAND												
	Fine	.125 - .25	SAND												
	Medium	.25 - .50	SAND												
	Coarse	.50 - 1.0	SAND												
	Very Coarse	1.0 - 2	SAND												
	Very Fine	2 - 4	GRAVEL												
.16 - .22	Fine	4 - 5.7	GRAVEL												
.22 - .31	Fine	5.7 - 8	GRAVEL												
.31 - .44	Medium	8 - 11.3	GRAVEL												
.44 - .63	Medium	11.3 - 16	GRAVEL												
.63 - .89	Coarse	16 - 22.6	GRAVEL												
.89 - 1.26	Coarse	22.6 - 32	GRAVEL												
1.26 - 1.77	Very Coarse	32 - 45	GRAVEL												
1.77 - 2.5	Very Coarse	45 - 64	GRAVEL												
2.5 - 3.5	Small	64 - 90	COBBLE												
3.5 - 5.0	Small	90 - 128	COBBLE												
5.0 - 7.1	Large	128 - 180	COBBLE												
7.1 - 10.1	Large	180 - 256	COBBLE												
10.1 - 14.3	Small	256 - 362	BOULDER												
14.3 - 20	Small	362 - 512	BOULDER												
20 - 40	Medium	512 - 1024	BOULDER												
40 - 80	Large-Vry Large	1024 - 2048	BOULDER												
	Bedrock		BDRK												
						TOTALS →									

Montgomery County DEP Fall Habitat Monitoring Data Sheet

4a. Longitudinal Profile (record %WW to nearest 10%)
(TL=Total Length, WW=Wetted Width, MWD= Maximum Water Depth, DD=Depositional Depth)

Habitat Type	TL (m)	% WW	Pool MWD	Pool DD	Comments

NOTE: Habitat types defined as riffle, run, and pool, exclusively. List predominant habitat under Habitat Type column. List additional, secondary, habitat types under comments.

4b. Longitudinal Profile (RB = Right Bank, LB = Left Bank) / (*Refer to bottom of page 1 for codes)*

Parameters	0m	25m	50m	75m
Wetted Width (ft)				
Channel Width (ft)				
Thalweg Depth (ft)				
LB Height (ft)				
LB % Vegetation				
LB Vegetation Type				
LB Bank Material				
RB Height (ft)				
RB % Vegetation				
RB Vegetation Type				
RB Bank Material				
% Canopy Cover				
Erosional / Depositional				

NOTE: Record percentages to nearest 10%. Record vegetation type and bank material in order of predominance (e.g., TR/GR/HB). Indicate which bank is the erosional vs. depositional side, respectively (e.g., RB/LB) or neither.

Habitat Assessment Field Data Sheet for Riffle/Run Prevalent Streams.

HABITAT ASSESSMENT FIELD DATA SHEET

RIFFLE/RUN PREVALENT STREAMS

STREAM ____________________ DATE ____________________

SITE ____________________ INVESTIGATOR ____________________

Riffle/Run Prevalent Streams are those in moderate to high gradient landscapes that sustain water velocities of approximately 1 ft/sec or greater. Natural streams have substrates primarily composed of coarse sediment particles (i.e., gravel or larger) or frequent coarse particulate aggregations along stream reaches.

Habitat Parameter	Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
1. Instream Cover (Fish)	Greater than 50% mix of snags, submerged logs, undercut banks, or other stable habitat.	30-50% mix of stable habitat; adequate habitat for maintenance of populations.	10-30% mix of stable habitat; habitat availability less than desirable.	Less than 10% mix of stable habitat; lack of habitat is obvious.
SCORE ___	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Epifaunal Substrate	Well-developed riffle and run; riffle is as wide as stream and length extends two times the width of stream; abundance of cobble.	Riffle is as wide as stream but length is less than two times width; abundance of cobble; boulders and gravel common.	Run area may be lacking; riffle not as wide as stream and its length is less than 2 times the stream width; gravel or large boulders and bedrock prevalent; some cobble present.	Riffles or run virtually nonexistent; large boulders and bedrock prevalent; cobble lacking.
SCORE ___	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Embeddedness	Gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 25-50% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 50-75% surrounded by fine sediment.	Gravel, cobble, and boulder particles are more than 75% surrounded by fine sediment.
SCORE ___	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Channel Alteration	Channelization or dredging absent or minimal; stream with normal, sinuous pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	New embankments present on both banks; and 40 to 80% of stream reach channel-ized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted.
SCORE ___	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Sediment Deposition	Little or no enlargement of islands or point bars and less than 5% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from coarse gravel; 5-30% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, coarse sand on old and new bars; 30-50% of the bottom affected; sediment deposits at obstruction, constriction, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 50% of the bottom changing frequendy; pools almost absent due to substantial sediment deposition.
SCORE ___	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

Habitat Parameter	Category			
	Optimal	Suboptimal	Marginal	Poor
6. Frequency of Riffles	Occurrence of riffles relatively frequent; distance between riffles divided by the width of the stream equals 5 to 7; variety of habitat.	Occurrence of riffles infrequent; distance between riffles divided by the width of the stream equals 7 to 15.	Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by the width of the stream is between 15 to 25.	Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is between ratio >25.
SCORE ____	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Channel Flow Status	Water reaches base of both lower banks and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE ____	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Vegetative Protection (score each bank) Note: determine left or right side by facing downstream.	More than 90% of the streambank surfaces covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption, through grazing or mowing, minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 2 inches or less in average stubble height.
SCORE ____ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ____ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
9. Bank Stability (score each bank)	Banks stable; no evidence of erosion or bank failure; little potential for future problems.	Moderately stable; infrequent, small areas of erosion mostly healed over.	Moderately unstable; up to 60% of banks in reach have areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE ____ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ____ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters; little or no riparian vegetation due to human activities.
SCORE ____ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ____ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0

Total Score ____

Versar Spring Habitat Data Sheet

Page ☐ Of

SITE Watershed Code ☐☐☐☐ Segment ☐☐☐ Type ☐ Year ☐☐☐☐

DATE Year ☐☐ Month ☐☐ Day ☐☐

Reviewed By: ____________

2nd Reviewer: ____________

☐☐☐☐ **Distance from Nearest Road to Site (m)**

☐☐ **Trash Rating 0 - 20**

RIPARIAN VEGETATION

(facing upstream)

LEFT BANK	RIGHT BANK	
☐☐	☐☐	Width (50m max)
☐☐	☐☐	Adjacent Land Cover (see back)
☐☐☐☐	☐☐☐☐	Vegetation Type (see back)
☐	☐	Buffer Breaks (Y/N)

Buffer Break Types
(M = minor; S = severe)

Left	Right	
☐	☐	Storm Drain
☐	☐	Tile Drain
☐	☐	Impervious Drainage
☐	☐	Gully
☐	☐	Orchard
☐	☐	Crop
☐	☐	Pasture
☐	☐	New Construction
☐	☐	Dirt Road
☐	☐	Gravel Road
☐	☐	Raw Sewage
☐	☐	Railroad

LANDUSE (Y/N)

- ☐ Old Field
- ☐ Deciduous Forest
- ☐ Coniferous Forest
- ☐ Wetland
- ☐ Surface Mine
- ☐ Landfill
- ☐ Residential
- ☐ Commercial/Industrial
- ☐ Cropland
- ☐ Pasture
- ☐ Orchard/Vineyard/Nursery
- ☐ Golf Course

Benthic Habitat Sampled

- ☐☐ Riffle
- ☐☐ Rootwad
- ☐☐ Leaf pack
- ☐☐ Macrophytes
- ☐☐ Undercut banks
- ☐☐ Other

Sample Labels
Benthos Label Verified By:
____

Water Quality
Temp (C) ☐☐.☐☐
DO (ppm) ☐☐.☐☐
pH ☐☐.☐☐
Cond (umho/cm) ☐.☐☐☐
Turbidity ☐☐☐.☐
Calibrated by:
____

CHANNELIZATION

☐ **Evidence of Channel Straightening or Dredging (Y/N)**

TYPE	EXTENT (m)		
	LEFT BANK	BOTTOM	RIGHT BANK
Concrete	☐☐	☐☐	☐☐
Gabion	☐☐	☐☐	☐☐
Rip-Rap	☐☐	☐☐	☐☐
Earthen Berm	☐☐	☐☐	☐☐
Dredge Spoil Off Channel	☐☐	☐☐	☐☐
Pipe Culvert	☐☐	☐☐	☐☐

MBSS SUMMER INDEX PERIOD DATA SHEET

Page ☐ Of ☐

SITE — Watershed Code ☐☐☐☐ Segment ☐☐☐ Type ☐ Year ☐☐☐☐

BASIN ☐☐ (see back for codes)

DATE — Year ☐☐ Month ☐☐ Day ☐☐

TIME ☐☐☐☐ (Military)

Reviewed By: ____________

2nd Reviewer: ____________

CREW: ____________

COMMENTS: ____________

SAMPLEABILITY

- s = Sampleable
- 1 = Dry Streambed
- 2 = Too Deep
- 3 = Marsh, no defined channel
- 4 = Excessive Riparian Vegetation
- 5 = Impoundment
- 6 = Tidally Influenced
- 7 = Permission Denied
- 8 = Unsafe (describe in comments)
- 9 = Beaver
- 10 = Other ____________

☐ Electrofishing

☐ Habitat Assessment

☐ Water Quality

☐ Herpetofauna

☐ Mussels

☐ Aquatic Plants

AQUATIC PLANTS

(A, P, or E)

Submerged Aquatic Vegetation ☐

Emergent Aquatic Vegetation ☐

Floating Aquatic Vegetation ☐

(Absent, Present, Extensive)

HERPETOFAUNA

Taxa Observed	Number retained or Photo
	☐
	☐
	☐
	☐
	☐
	☐
	☐
	☐

MUSSELS

Taxa Observed	(N,O,R, or L)	Retained? (Y/N)
Unionids	☐	☐
Corbicula	☐	☐

None, Old Shell, Recent Shell, Live

WATER QUALITY

Temp (C) ☐☐.☐

DO (ppm) ☐☐.☐

pH ☐☐.☐☐

Cond (umho/cm) ☐.☐☐☐

Turbidity (NTU) ☐☐☐.☐

Meter Calibrations by: ____________

MBSS SUMMER HABITAT DATA SHEET

Page ☐ Of ☐

SITE Watershed Code ☐☐☐☐ Segment ☐☐☐ Type ☐ Year ☐☐☐☐

Reviewed By: ____________

BASIN ☐☐ (see back for codes)

2nd Reviewer: ____________

DATE Year ☐☐ Month ☐☐ Day ☐☐

CREW: ____________

TIME ☐☐☐☐ (Military)

BANK EROSION

	Left Bank	Right Bank
Extent (m)	☐☐	☐☐
Severity (1=min, 2=mod, 3=severe)	☐	☐
Eroded Area (m^2) x 10	☐☐☐	☐☐☐

BAR FORMATION & SUBSTRATE

- ☐ None
- ☐ Minor
- ☐ Moderate
- ☐ Extensive
- ☐ Cobble
- ☐ Gravel
- ☐ Sand
- ☐ Silt/Clay

EXOTIC PLANTS Relative Abundance (A, P, E)

- ☐ Multiflora Rose
- ☐ Mile-a-Minute
- ☐ Japanese Honeysuckle
- ☐ Phragmites
- ☐ Thistle
- ☐ Japanese Stilt Grass
- ☐ ____________

- ☐☐ No. of Instream Woody Debris
- ☐☐ No. of Dewatered Woody Debris
- ☐☐ No. of Instream Rootwads
- ☐☐ No. of Dewatered Rootwads

HABITAT ASSESSMENT

1. Instream Habitat (0-20) ☐☐
2. Epifaunal Substrate (0-20) ☐☐
3. Velocity/Depth Diversity (0-20) ☐☐
4. Pool/Glide/Eddy Quality (0-20) ☐☐
   Extent (m) ☐☐
5. Riffle/Run Quality (0-20) ☐☐
   Extent (m) ☐☐
6. Embeddedness (%) ☐☐☐
7. Shading (%) ☐☐☐

STREAM CHARACTER

- ☐ Braided
- ☐ Riffle
- ☐ Run/Glide
- ☐ Deep Pool(>= .5m)
- ☐ Shallow Pool(< .5m)
- ☐ Boulder >2m
- ☐ Boulder <2m
- ☐ Cobble
- ☐ Bedrock
- ☐ Gravel
- ☐ Sand
- ☐ Silt/Clay
- ☐ Undercut Bank
- ☐ Overhead Cover
- ☐ Beaver Pond

A = Absent
P = Present
E = Extensive

Maximum Depth (cm) ☐☐☐

	Wetted Width (m)	Thalweg Depth (cm)	Thalweg Velocity (m/s)
0 m	☐☐.☐	☐☐☐	☐.☐☐
25 m	☐☐.☐	☐☐☐	☐.☐☐
50 m	☐☐.☐	☐☐☐	☐.☐☐
75 m	☐☐.☐	☐☐☐	☐.☐☐

FLOW

Lat Loc (m)	Depth (cm)	Velocity (m/s)
0 0 . 0 0	0 0 . 0	0 . 0 0

Alternative Flow Measurements

Distance

Depth (cm) ☐

Width (cm) ☐☐

Time (sec) 1. ☐☐☐ 2. ☐☐☐ 3. ☐☐☐

COMMENTS ____________

MBSS FISH DATA SHEET

Page ___ Of ___

SITE Watershed Code ____ Segment ___ Type _ Year ____

Reviewed By: ______________

DATE Y Y M M D D

2nd Reviewer: ______________

	(Y/N)
Fish Move. During Net Install.?	
Bottom Visible in all Areas of Seg.?	
Same Water Clarity - 2nd Pass?	
Volt. ____ Waveform	
Len. of Seg. Actually Samp. (m)	

	Unit ___	Unit ___	Unit ___	Unit ___	Unit ___
Anodes/Unit					
Time (sec) Begin 1[st] p.					
Begin 2[nd] p.					
End 2[nd] p.					

SPECIES (See Back for Name Spelling)	Number Retained? or Photo	1st Pass Catch (Total)	2nd Pass Catch (Total)	Unusual Anomalies (Y/N)	Comments
Fish Captured? (Y/N)					
Aggregate Fish Biomass				(g)	

MBSS GAME FISH LENGTH DATA SHEET

Page ___ Of ___

SITE Watershed Code ____ Segment ___ Type _ Year ____

DATE Y Y M M D D

Reviewed By: ______________

2nd Reviewer: ______________

SPECIES	LENGTH (TL; mm)	SPECIES	LENGTH (TL; mm)
1.		31.	
2.		32.	
3.		33.	
4.		34.	
5.		35.	
6.		36.	
7.		37.	
8.		38.	
9.		39.	
10.		40.	
11.		41.	
12.		42.	
13.		43.	
14.		44.	
15.		45.	
16.		46.	
17.		47.	
18.		48.	
19.		49.	
20.		50.	
21.		51.	
22.		52.	
23.		53.	
24.		54.	
25.		55.	
26.		56.	
27.		57.	
28.		58.	
29.		59.	
30.		60.	

FISH CRIB SHEET

Page ___ Of ___

	Watershed Code	Segment	Type	Year
SITE				

	Y Y	M M	D D
DATE			

___ PASS			___ PASS		
Species	Tally	Anomalies	Species	Tally	Anomalies

MBSS Stream Habitat Assessment Guidance Sheet				
Habitat Parameter	Optimal 16-20	Sub-Optimal 11-15	Marginal 6-10	Poor 0-5
1. Instream Habitat[a]	Greater than 50% of a variety of cobble, boulder, submerged logs, undercut banks, snags, rootwads, aquatic plants, or other stable habitat	30-50% of stable habitat. Adequate habitat	10-30% mix of stable habitat. Habitat availability less than desirable	Less than 10% stable habitat. Lack of habitat is obvious
2. Epifaunal Substrate[b]	Preferred substrate abundant, stable, and at full colonization potential (riffles well developed and dominated by cobble; and/or woody debris prevalent, not new, and not transient)	Abund. of cobble with gravel &/or boulders common; or woody debris, aquatic veg., undercut banks, or other productive surfaces common but not prevalent /suited for full colonization	Large boulders and/or bedrock prevalent; cobble, woody debris, or other preferred surfaces uncommon	Stable substrate lacking; or particles are over 75% surrounded by fine sediment or flocculent material
3. Velocity/Depth Diversity[c]	Slow (<0.3 m/s), deep (>0.5 m); slow, shallow (<0.5 m); fast (>0.3 m/s), deep; fast, shallow habitats all present	Only 3 of the 4 habitat categories present	Only 2 of the 4 habitat categories present	Dominated by 1 velocity/depth category (usually pools)
4. Pool/Glide/Eddy Quality[d]	Complex cover/&/or depth > 1.5 m; both deep (> .5 m)/shallows (< .2 m) present	Deep (>0.5 m) areas present; but only moderate cover	Shallows (<0.2 m) prevalent in pool/glide/eddy habitat; little cover	Max depth <0.2 m in pool/glide/eddy habitat; or absent completely
5. Riffle/Run Quality[e]	Riffle/run depth generally >10 cm, with maximum depth greater than 50 cm (maximum score); substrate stable (e.g. cobble, boulder) & variety of current velocities	Riffle/run depth generally 5-10 cm, variety of current velocities	Riffle/run depth generally 1-5 cm; primarily a single current velocity	Riffle/run depth < 1 cm; or riffle/run substrates concreted
6. Embeddedness[f]	Percentage that gravel, cobble, and boulder particles are surrounded by fine sediment or flocculent material.			
7. Shading[g]	Percentage of segment that is shaded (duration is considered in scoring). 0% = fully exposed to sunlight all day in summer; 100% = fully and densely shaded all day in summer			
8. Trash Rating[h]	Little or no human refuse visible from stream channel or riparian zone	Refuse present in minor amounts	Refuse present in moderate amounts	Refuse abundant and unsightly

a) Instream Habitat Rated based on perceived value of habitat to the fish community. Within each category, higher scores should be assigned to sites with a variety of habitat types and particle sizes. In addition, higher scores should be assigned to sites with a high degree of hypsographic complexity (uneven bottom). In streams where ferric hydroxide is present, instream habitat scores are not lowered unless the precipitate has changed the gross physical nature of the substrate. In streams where substrate types are favorable but flows are so low that fish are essentially precluded from using the habitat, low scores are assigned. If none of the habitat within a segment is useable by fish, a score of zero is assigned.

b) Epifaunal Substrate Rated based on the amount and variety of hard, stable substrates usable by benthic macroinvertebrates. Because they inhibit colonization, floculent materials or fine sediments surrounding otherwise good substrates are assigned low scores. Scores are also reduced when substrates are less stable.

c) Velocity/Depth Diversity Rated based on the variety of velocity/depth regimes present at a site (slow-shallow, slow-deep, fast-shallow, and fast-deep). As with embeddedness, this metric may result in lower scores in low-gradient streams but will provide a statewide information on the physical habitat found in Maryland streams.

d) <u>Pool/Glide/Eddy Quality</u> Rated based on the variety and spatial complexity of slow- or still-water habitat within the sample segment. It should be noted that even in high-gradient segments, functionally important slow-water habitat may exist in the form of larger eddies. Within a category, higher scores are assigned to segments which have undercut banks, woody debris or other types of cover for fish.

e) <u>Riffle/Run Quality</u> Rated based on the depth, complexity, and functional importance of riffle/run habitat in the segment, with highest scores assigned to segments dominated by deeper riffle/run areas, stable substrates, and a variety of current velocities.

f) <u>Embeddedness</u> Rated as a percentage based on the fraction of surface area of larger particles that is surrounded by fine sediments on the stream bottom. In low gradient streams with substantial natural deposition, the correlation between embeddedness and fishability or ecological health may be weak or non-existent, but this metric is rated in all streams to provide similar information from all sites statewide.

g) <u>Shading</u> Rated based on estimates of the degree and duration of shading at a site during summer, including any effects of shading caused by landforms.

h) <u>Trash Rating</u> The scoring of this metric is based on the amount of human refuse in the stream and along the banks of the sample segment.

MBSS Drainage Basin Codes

YG = Youghiogheny River
NO = North Branch Potomac River
UP = Upper Potomac River
MP = Middle Potomac River
CO = Conawago Creek
PW = Potomac Washington Metro
LP = Lower Potomac River
PX = Patuxent River
WC = West Chesapeake
PP = Patapsco River
BU = Bush River
GU = Gunpowder River
SQ = Lower Susquehanna River
EL = Elk River
CR = Chester River
CK = Choptank River
NW = Nanticoke-Wicomico Rivers
PC = Pocomoke River
OC = Ocean Coastal

Watershed	Abbreviation
Aberdeen Proving Ground	ABPG
Anacostia River	ANAC
Antietam Creek	ANTI
Assawoman Bay	ASSA
Atkisson Reservoir	ATKI
Atlantic Ocean	ATLA
Back River	BACK
Back Creek	BACR
Baltimore Harbor	BALT
Big Annemessex River	BANN
Big Elk Creek	BELK
Bird River	BIRD
Bodkin Creek	BODK
Bohemia River	BOHE
Breton Bay	BRET
Brighton Dam	BRIG
Broad Creek	BROA
Bush River	BUSH
Bynum Run	BYNU
Cabin John Creek	CABJ
Casselman River	CASS
Catoctin Creek	CATO
Conowingo Dam Susquehanna R	CDAM
Chincoteague Bay	CHIN
Christina River	CHRI
Conewago Creek	COCR
Conococheague	CONO
Corsica River	CORS
Deep Creek Lake	DCRL
Deer Creek	DEER
Dividing Creek	DIVI
Double Pipe Creek	DOUB
Eastern Bay	EAST
Evitts Creek	EVIT
Fifteen Mile Creek	FIMI
Fishing Bay	FISH
Furnace Bay	FURN
Georges Creek	GEOR
Gilbert Swamp	GILB
Gunpowder River	GUNP
Gwynns Falls	GWYN
Honga River	HONG
Isle of Wight Bay	ISLE
Jones Falls	JONE
Kent Island Bay	KEIS
Kent Narrows	KENA
Langford Creek	LANG
Little Conococheague	LCON
Liberty Reservoir	LIBE
Little Choptank	LICK
Little Elk Creek	LIEL
Little Gunpowder Falls	LIGU
Licking Creek	LIKG
Lower Monocacy River	LMON
Loch Raven Reservoir	LOCH
Lower Choptank	LOCK
Lower Chester River	LOCR
Lower Elk River	LOEL
Lower Gunpowder Falls	LOGU
Lower Pocomoke River	LOPC
Lower Wicomico	LOWI
Little Patuxent River	LPAX
Lower Susquehanna	LSUS
Little Tonoloway	LTON
Lower Chesapeake Bay	LWCH
Lower Winters Run	LWINT
Little Youghiogheny	LYOU
Magothy River	MAGO
Manokin River	MANO
Marsh Run	MARS
Marshyhope Creek	MACK
Mattawoman Creek	MATT
Middle Chesapeake Bay	MDCH
Middle Chester River	MICR
Middle River-Browns	MIDD
Miles River	MILE
Monie Bay	MONI
Middle Patuxent River	MPAX
Nanjemoy Creek	NANJ
Nanticoke River	NANT
Nassawango Creek	NASS
Northeast River	NEAS
Newport Bay	NEWP
Octoraro Creek	OCTO
Oxon Creek	OXON
Patapsco River Lower North Br	PATL
Patuxent River Lower	PAXL
Patuxent River Middle	PAXM
Patuxent River Upper	PAXU
Pocomoke Sound	PCSO
Piscataway Creek	PISC
Potomac AL Co	PRAL
Prettyboy Reservoir	PRET
Potomac River FR Co	PRFR
Potomac River Lower North Br	PRLN
Potomac Lower Tidal	PRLT
Potomac River MO Co	PRMO
Potomac River Middle Tidal	PRMT
Potomac River Upper North Br	PRUN
Potomac Upper Tidal	PRUT
Potomac WA Co	PRWA
Port Tobacco River	PTOB
Rocky Gorge Dam	RKGR
Rock Creek	ROCK
Sassafras River	SASS
Savage River	SAVA
South Branch Patapsco	SBPA
Southeast Creek	SEAS
Seneca Creek	SENE
Severn River	SEVE
Sideling Hill Creek	SIDE
Sinepuxent Bay	SINE
South River	SOUT
St. Clement Bay	STCL
Stillpond-Fairlee	STILL
St. Mary's River	STMA
Swan Creek	SWAN
Tangier Sound	TANG
Tonoloway	TONO
Town Creek	TOWN
Transquaking River	TRAN
Tuckahoe Creek	TUCK
Upper Elk River	UELK
Upper Monocacy River	UMON
Upper Chesapeake Bay	UPCH
Upper Choptank	UPCK
Upper Chester River	UPCR
Upper Pocomoke River	UPPC
West Chesapeake Bay	WCHE
Western Branch	WEBR
West River	WEST
Wicomico River	WICO
Wicomico Creek	WICR
Wills Creek	WILL
Wicomico River Head	WIRH
Wye River	WYER
Youghiogheny River	YOUG
Zekiah Swamp	ZEKI

VEGETATION TYPES

G= Grasses/Forbes
R= Regen Deciduous/Shrubs (<4"dbh)
Y= Young Deciduous (4-12" DBH)
M= Mature Deciduous (12-24" DBH
O= Old Deciduous (>24" DBH)
A= Regen Coniferous (<4" DBH)
B= Young Coniferous (4-12" DBH)
C= Mature Coniferous (12-24" DBH
D= Old Coniferous (>24" DBH)
L= Lawn

Riparian Buffer Zone/ Adjacent Land Cover Types

FR = Forest
OF = Old Field
EM = Emergent Vegetation
LN = Mowed Lawn
TG = Tall Grass
LO = Logged Area
SL = Bare Soil
RR = Railroad
PV = Paved Road
PK = Parking Lot/ Industrial/ Commerical
GR = Gravel Road
DI = Dirt Road
PA = Pasture
OR = Orchard
CP = Cropland
HO = Housing

Site Type

R = Random
T = Targeted
S = Sentinel

INSTREAM BLOCKAGE CODES

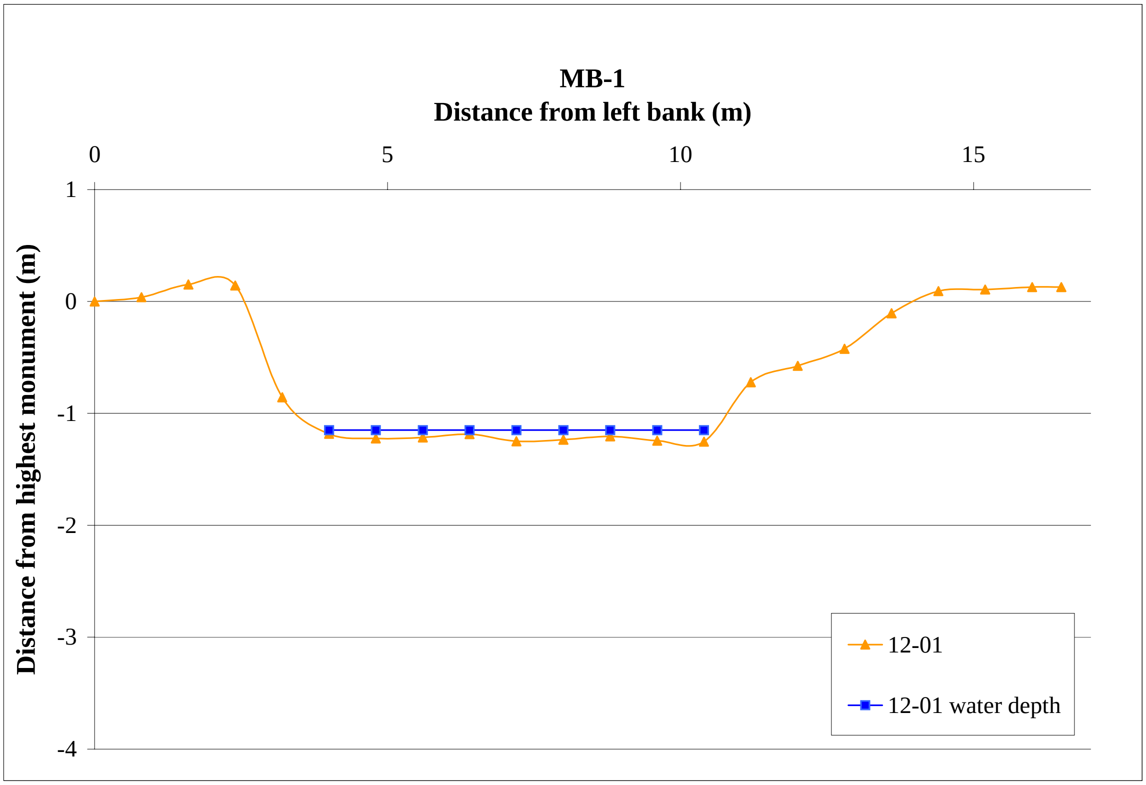
DM = Dam
PC = Pipe Culvert
F = Fishway
GW =Gaging Station Weir
G = Gabion
PX = Pipeline Crossing
AC = Arch Culvert
BC = Box Culvert
TG = Tide Gate

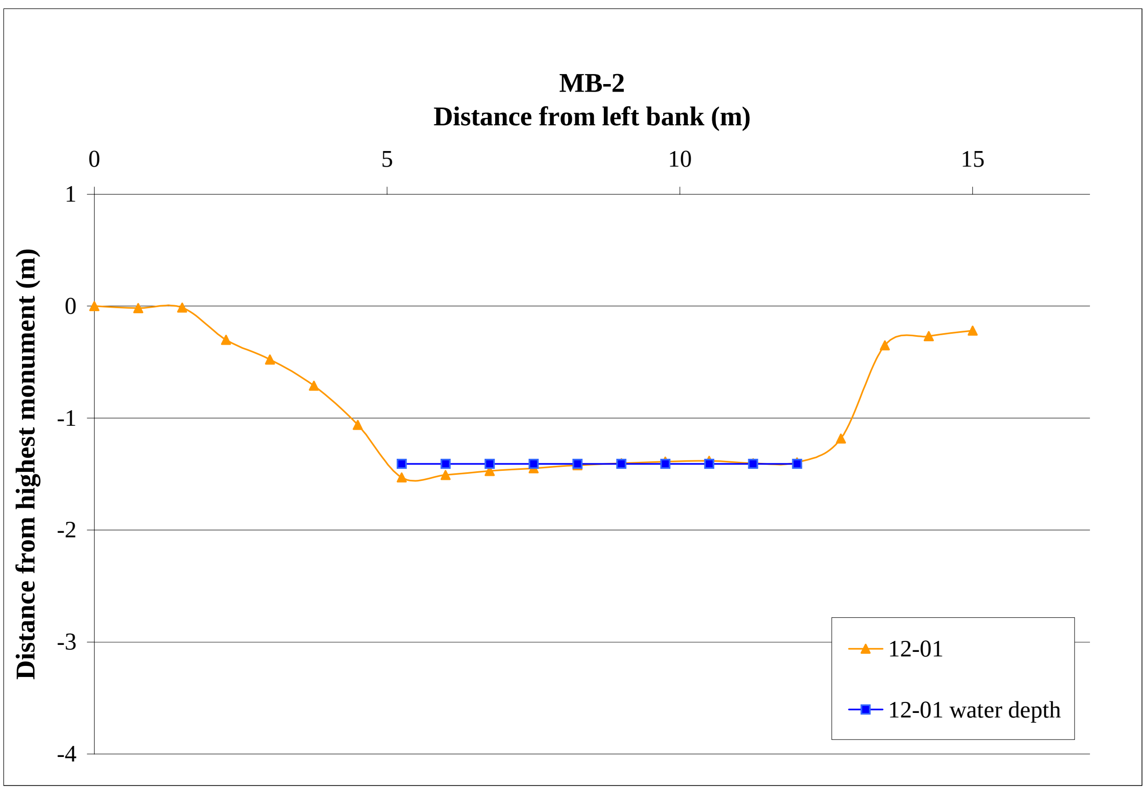
(Note: Height is measured in meters from stream surface to water surface above structure)

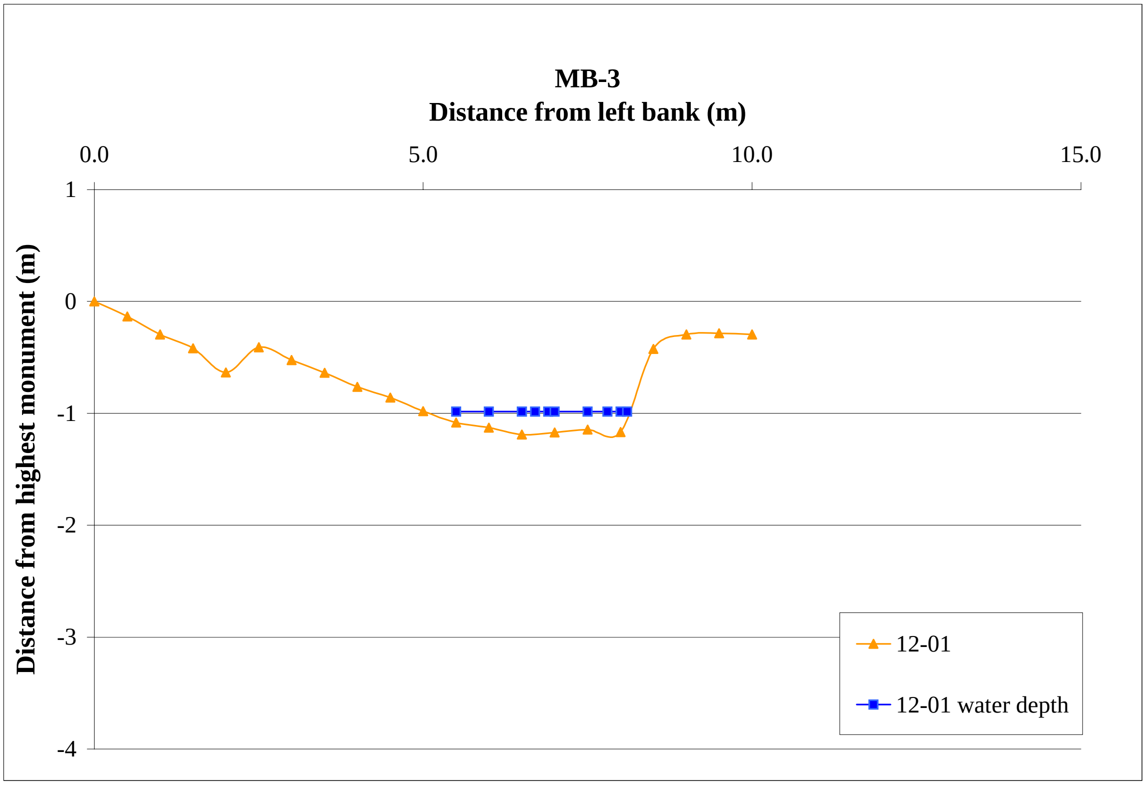
APPENDIX B

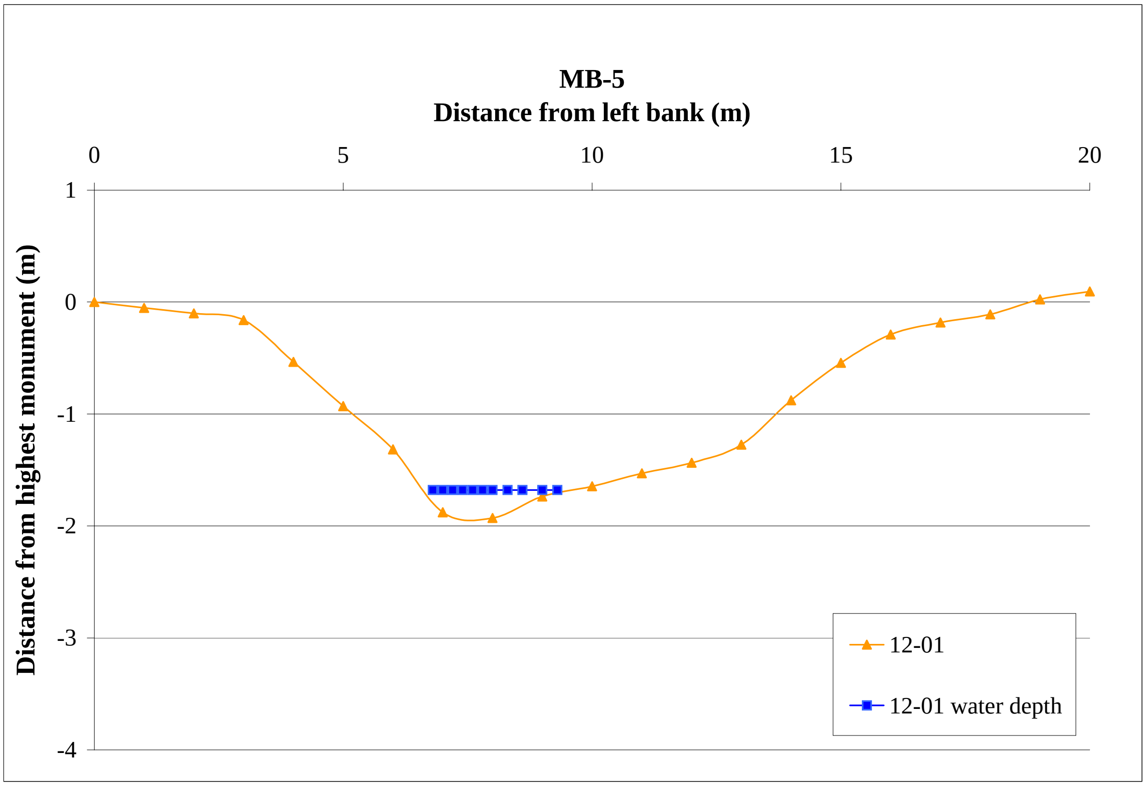
CROSS-SECTION PROFILES

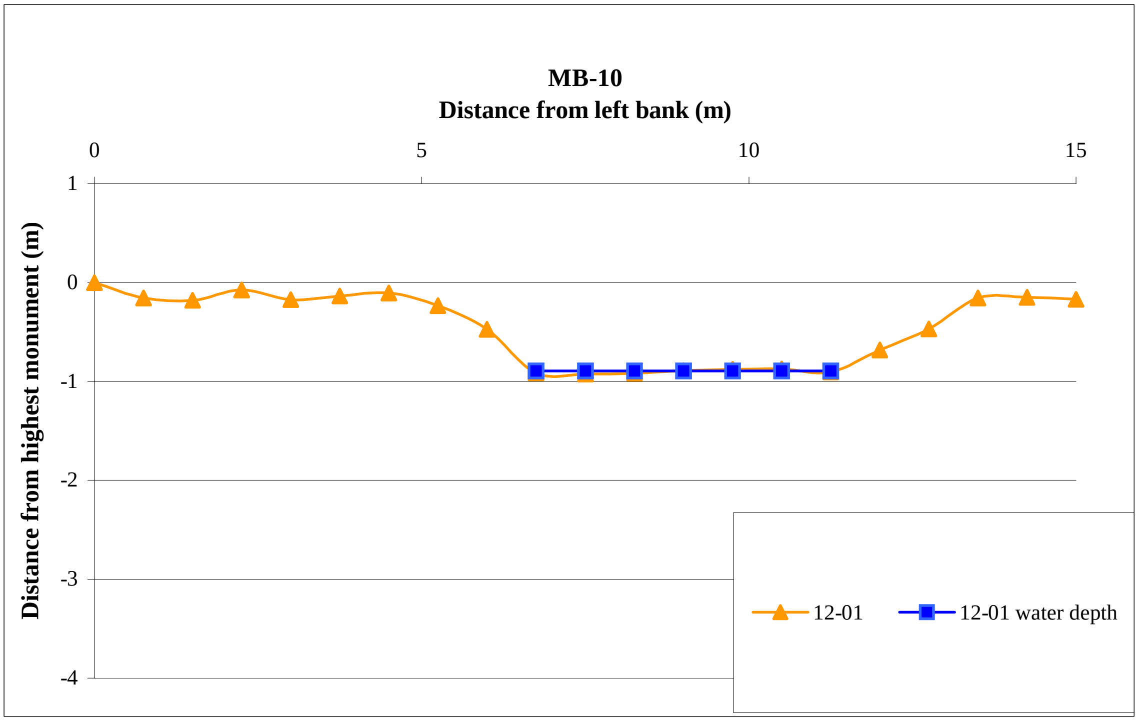
Random Sites

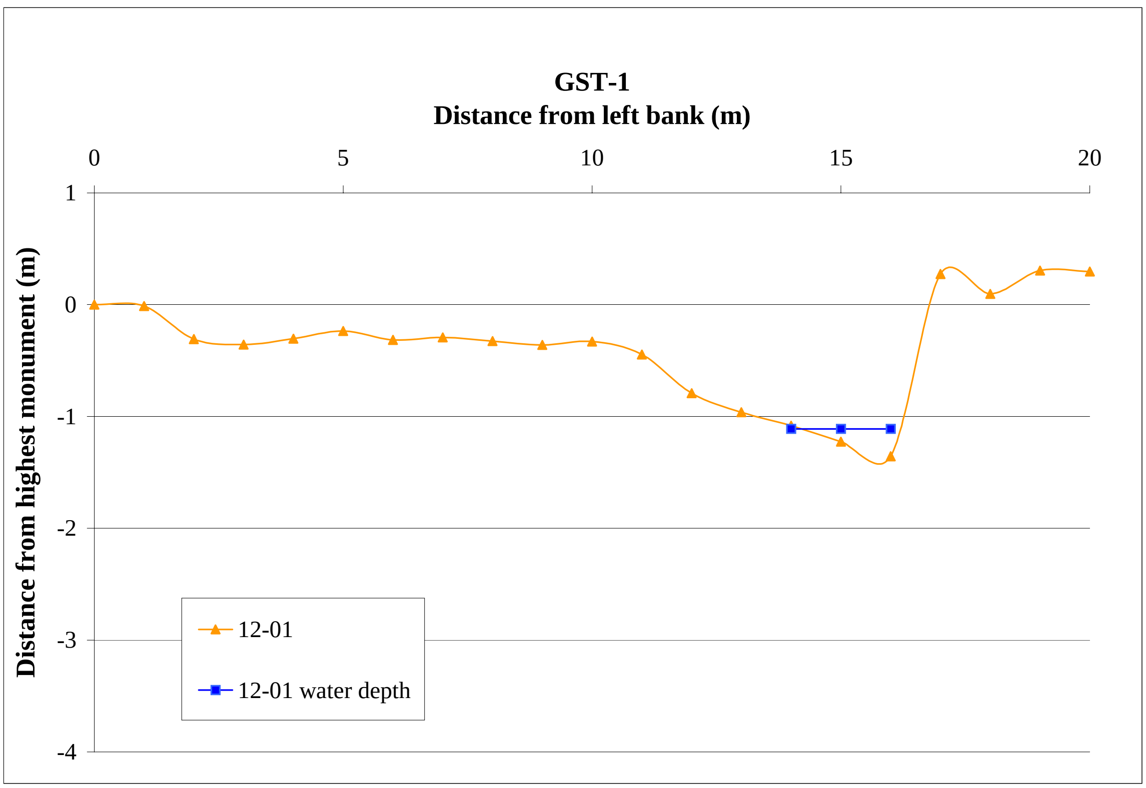


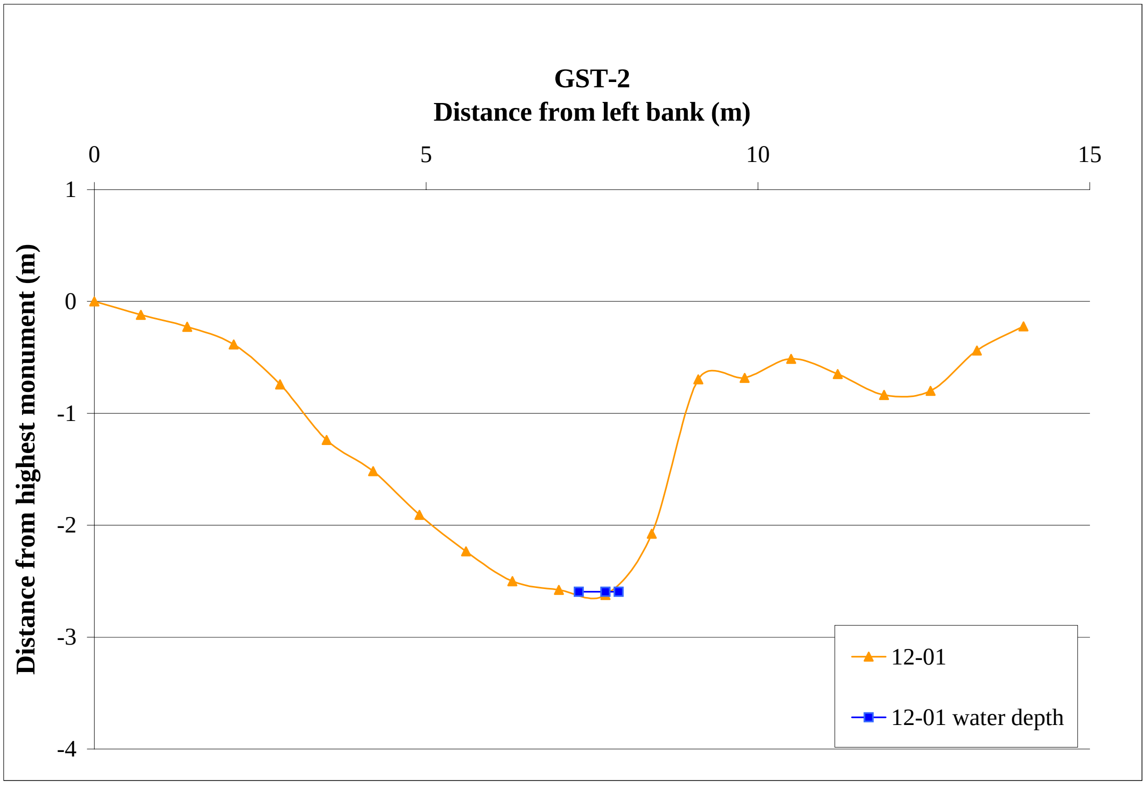


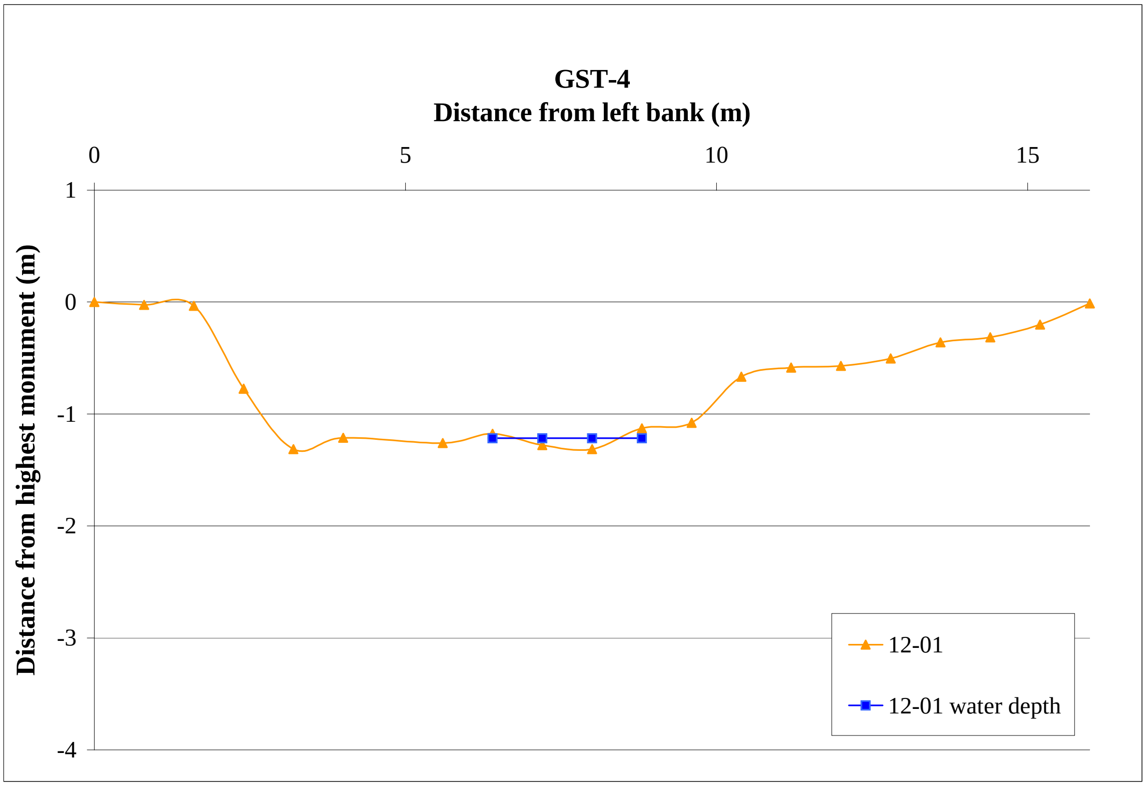

MB-3
Distance from left bank (m)
0.0
5.0
10.0
15.0
1
0
-1
-2
-3
-4
Distance from highest monument (m)
12-01
12-01 water depth

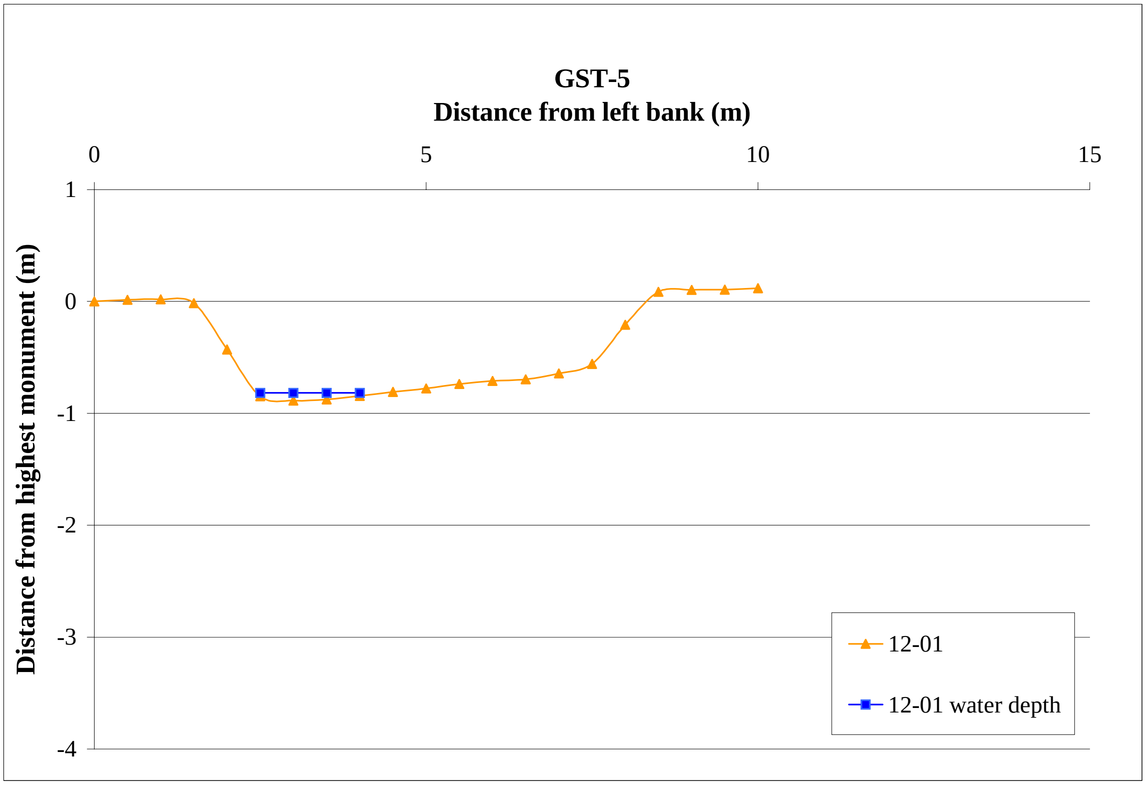

MB-5
Distance from left bank (m)
0
5
10
15
20
1
0
-1
-2
-3
-4
Distance from highest monument (m)
12-01
12-01 water depth

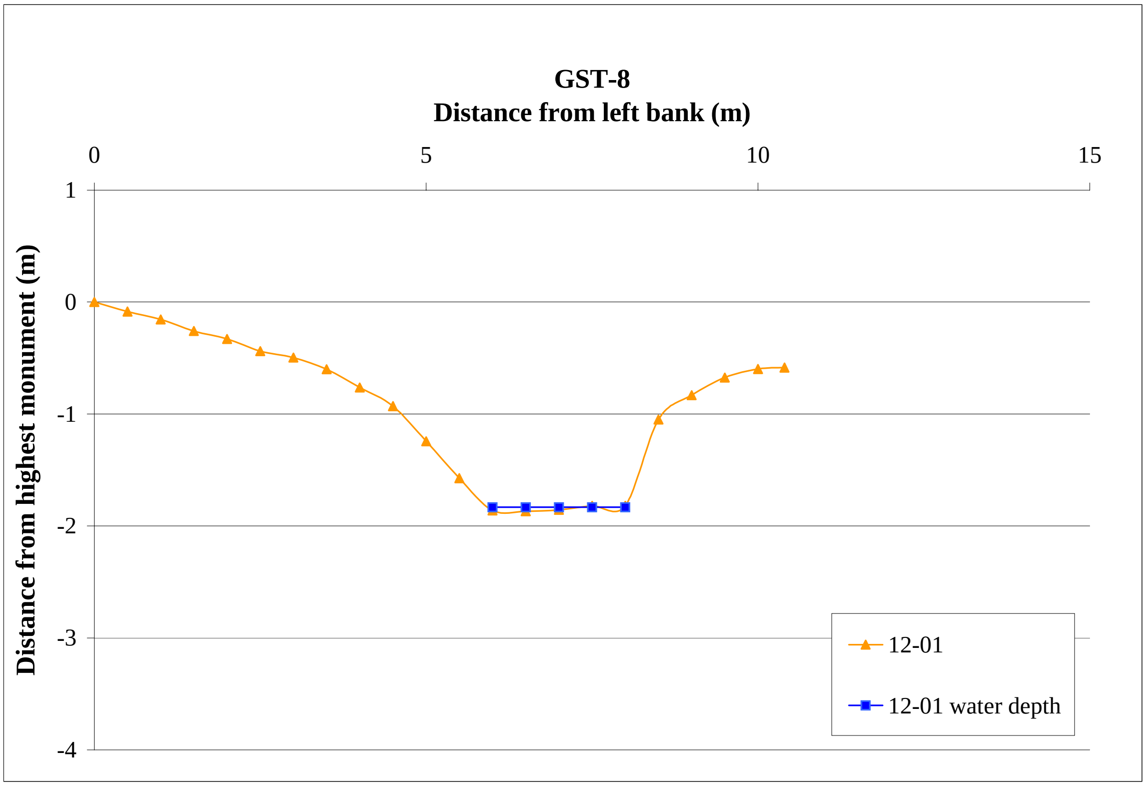

MB-10
Distance from left bank (m)
0
5
10
15
1
0
-1
-2
-3
-4
Distance from highest monument (m)
12-01
12-01 water depth


GST-1
Distance from left bank (m)
0
5
10
15
20
1
0
-1
-2
-3
-4
Distance from highest monument (m)
12-01
12-01 water depth

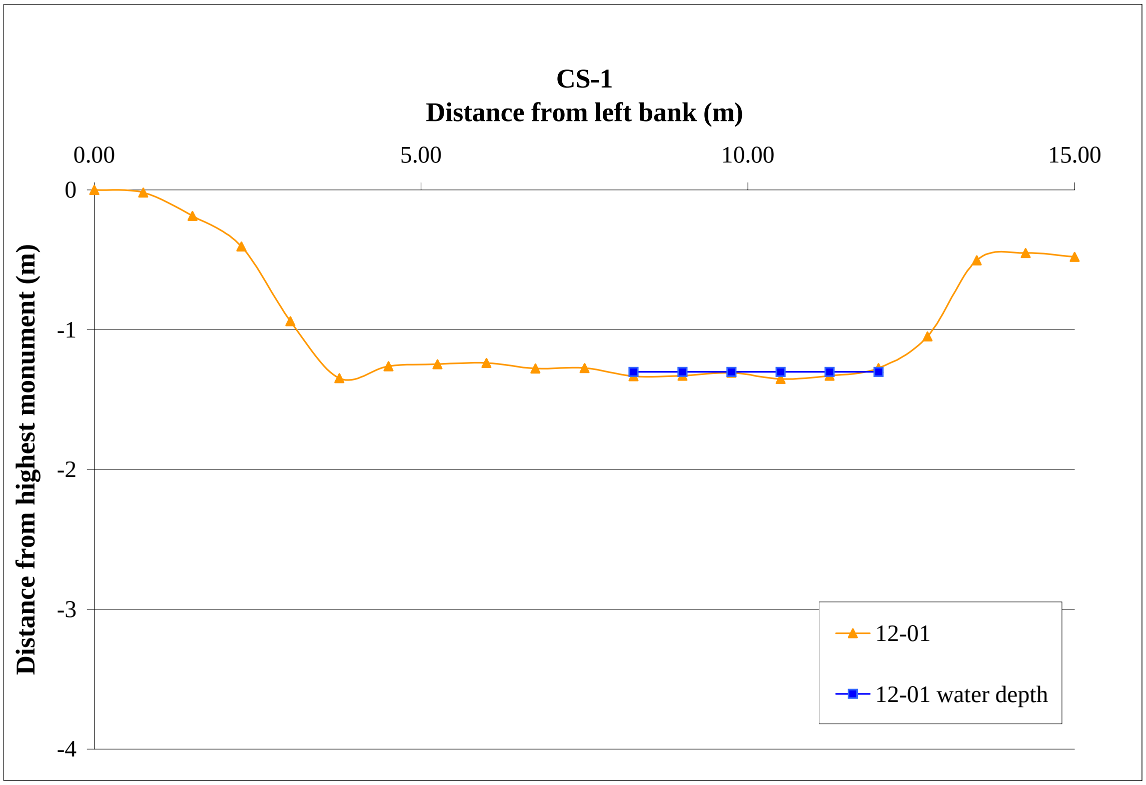

GST-2
Distance from left bank (m)
0
5
10
15
1
0
-1
-2
-3
-4
Distance from highest monument (m)
12-01
12-01 water depth

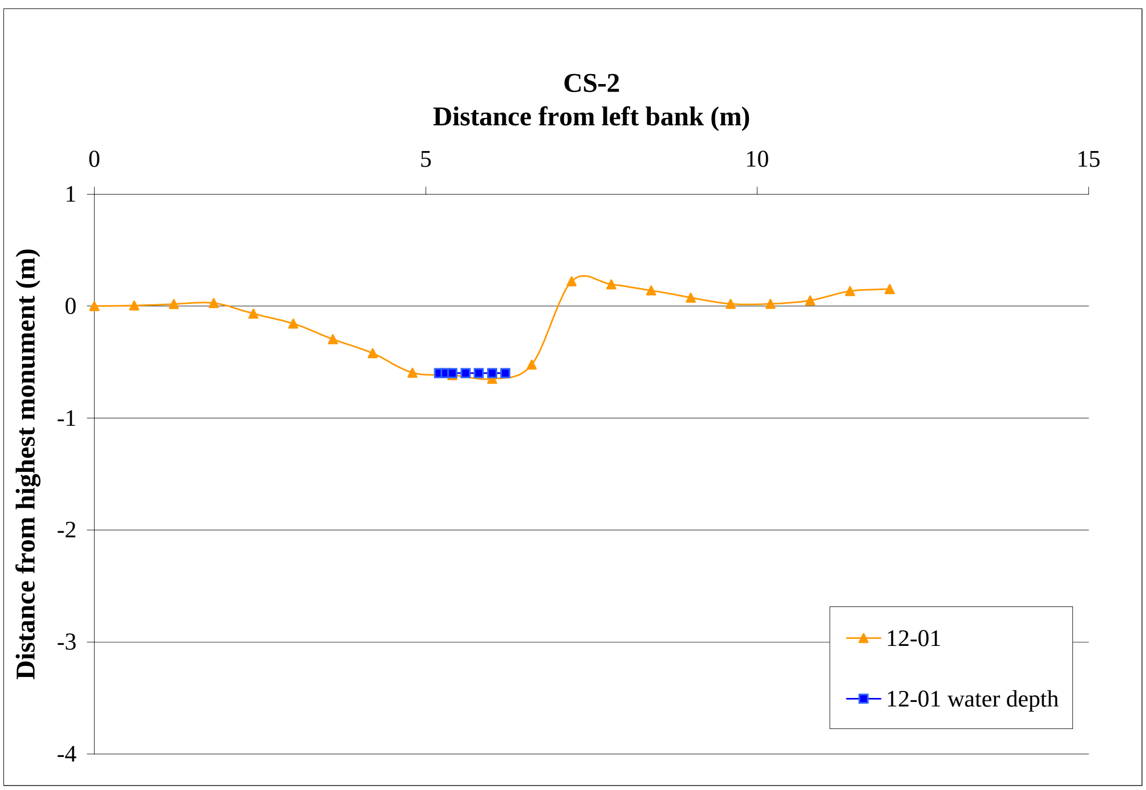

GST-4
Distance from left bank (m)
0
5
10
15
1
0
-1
-2
-3
-4
Distance from highest monument (m)
12-01
12-01 water depth

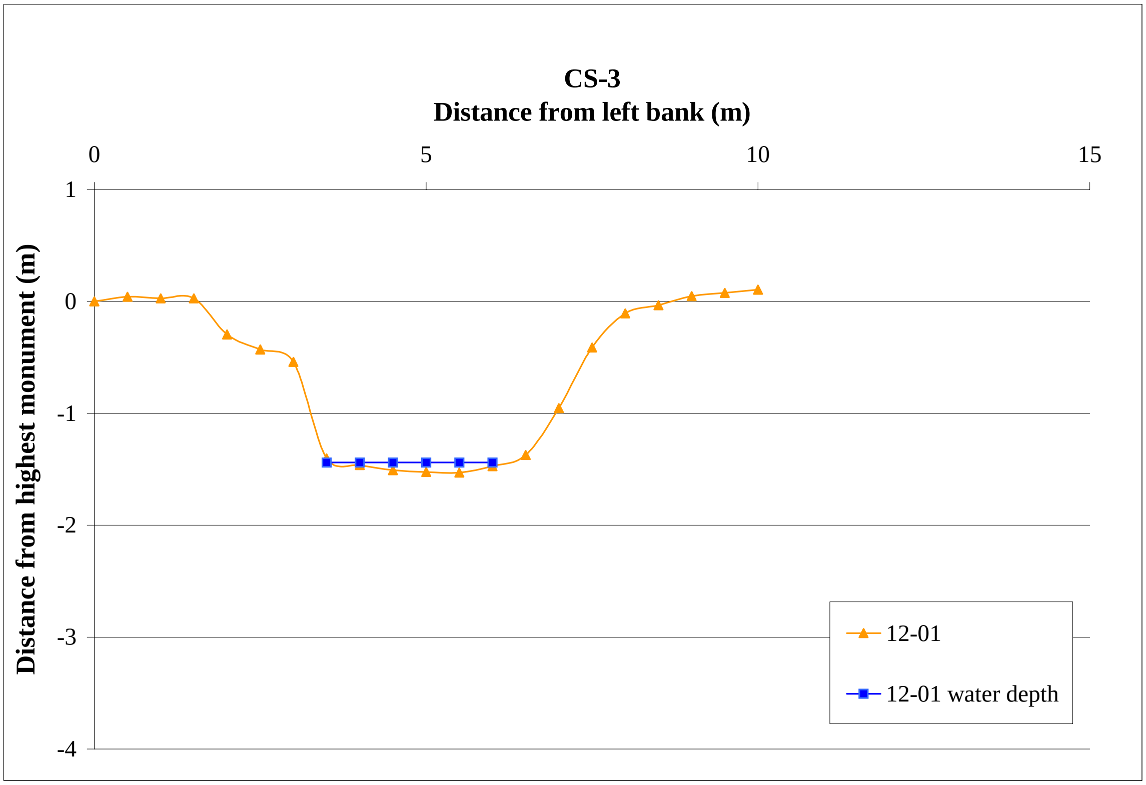

GST-5
Distance from left bank (m)
0
5
10
15
1
0
-1
-2
-3
-4
Distance from highest monument (m)
12-01
12-01 water depth

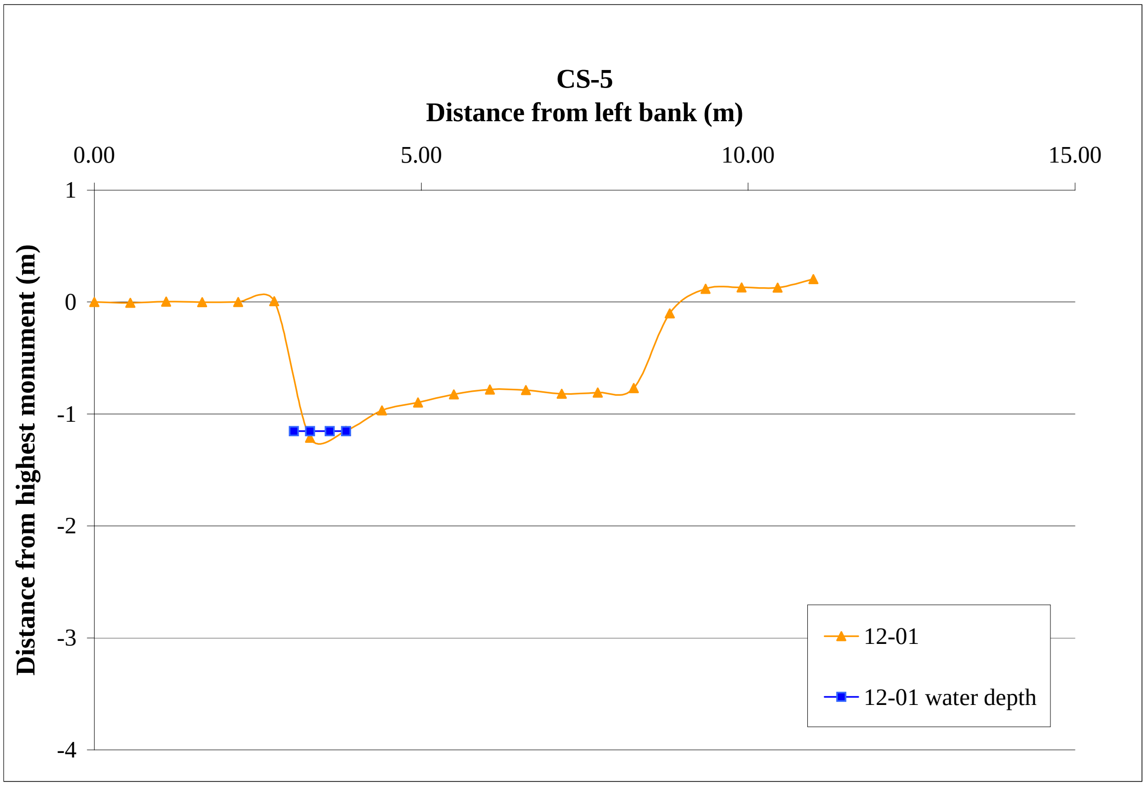

GST-8
Distance from left bank (m)
0
5
10
15
1
0
-1
-2
-3
-4
Distance from highest monument (m)
12-01
12-01 water depth

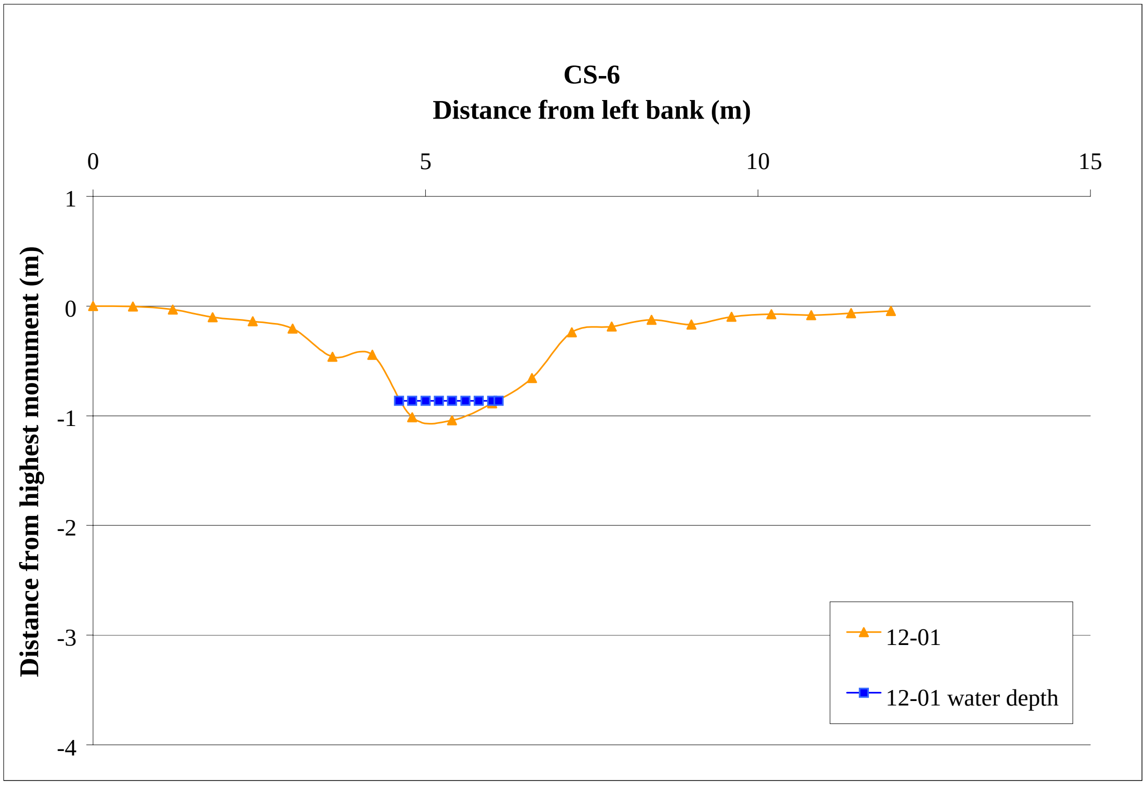
Targeted Sites

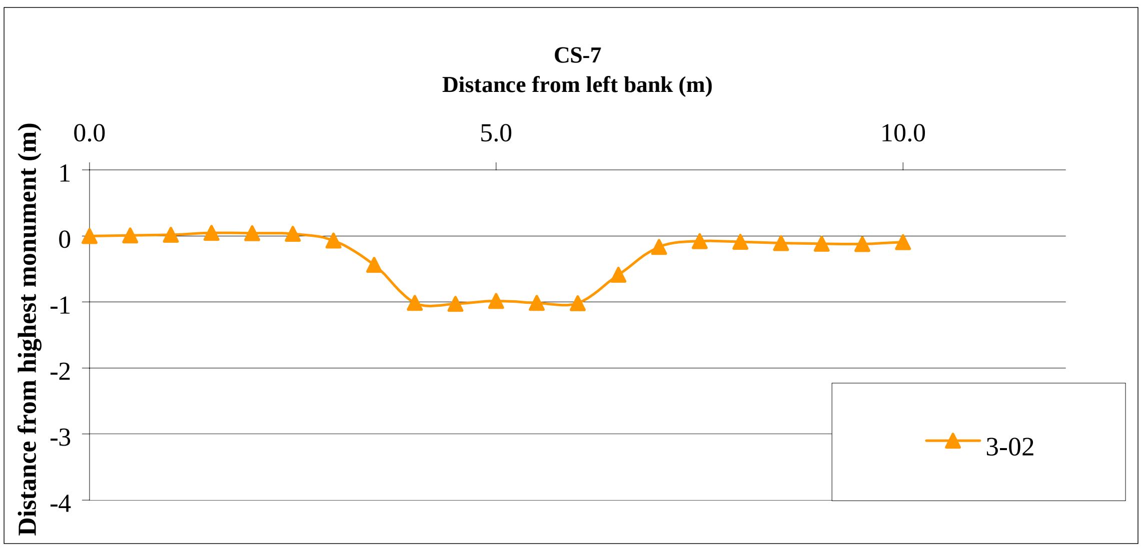


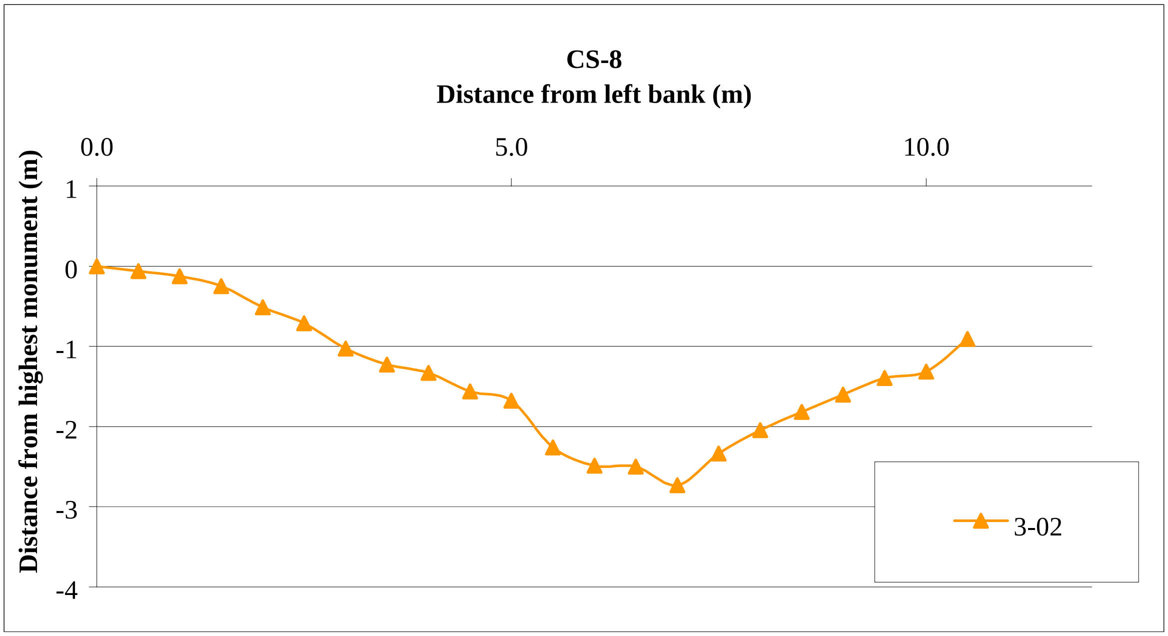



CS-3
Distance from left bank (m)
0
5
10
15
1
0
-1
-2
-3
-4
Distance from highest monument (m)
12-01
12-01 water depth


CS-5
Distance from left bank (m)
0.00
5.00
10.00
15.00
1
0
-1
-2
-3
-4
Distance from highest monument (m)
12-01
12-01 water depth


CS-6
Distance from left bank (m)
0
5
10
15
1
0
-1
-2
-3
-4
Distance from highest monument (m)
12-01
12-01 water depth


CS-7
Distance from left bank (m)
0.0
5.0
10.0
1
0
-1
-2
-3
-4
Distance from highest monument (m)
3-02


CS-8
Distance from left bank (m)
0.0
5.0
10.0
Distance from highest monument (m)
1
0
-1
-2
-3
-4
3-02

APPENDIX C

BENTHIC TAXA LIST

Table C-1. List of benthic taxa identified, by station, for Gaithersburg 2002 spring sampling. Tolerance values are scored from 0 to 10, with 10 being the most tolerant taxa

Phylum	Class	Order	Family	Name	Common Name	Feeding Group	Tolerance Value	MB-1	MB-2	MB-3	MB-5	MB-10	GST-1	GST-2	GST-4	GST-5	GST-8	CS-1	CS-2	CS-3	CS-5	CS-6	CS-7	CS-8	Total
Annelida	Oligochaeta	Haplotaxida	Enchytraeidae	Enchytraeidae	Worm	Collector	10	2					1				1		10	2					16
			Naididae	Pristina	Worm	Collector	10							1											1
				Pristinella	Worm	Collector	10							2											2
				Slavina	Worm	Collector	10						1				1							1	3
		Lumbricina	Lumbricidae	Lumbricidae	Worm	Collector	10											4	2	1	4				11
				Lumbriculus	Worm	Collector	10							1											1
		Lumbriculida	Lumbriculidae	Eclipidrilus	Worm	Collector	10		1					1											2
		Tubificida	Naididae	Dero	Worm	Collector	10							1		2	1								4
				Nais	Worm	Collector	10	8	26		8		20	9	51	3	4	1	1			6	5	8	150
			Tubificidae	Aulodrilus	Worm	Collector	10																1		1
				Limnodrilus	Worm	Collector	10	1		13	2									7	2				25
				Spirosperma	Worm	Collector	10										4								4
				Immature w/ hair chaetae	Worm	Collector	10													4					4
				Immature w/o hair chaetae	Worm	Collector	10	3		2							12	2		17	3	15			54
Arthopoda	Insecta	Coleoptera	Elmidae	Stenelmis	Beetle	Scraper	6	1				7	1							1					10
		Diptera	Ceratopogonidae	Dasyhelea	Biting Midge												1								1
			Chaoboridae	Chaoborus	Phantom Midge	Predator																	1		1
			Chironomidae	Ablabesmyia	Midge	Predator	8	1		9						1				1	3				15
				Brillia	Midge	Shredder	5	3	1								1	2				2			9
				Chaetocladius	Midge	Collector	6								1	2	3							1	7
				Chironomus	Midge	Collector	10	2		1									3	5					11
				Conchapelopia	Midge	Predator	6	1		8	1		3	7		1		4	1	14	2	4	2	1	49
				Corynoneura	Midge	Collector	7					1			3		1						3	1	9
				Cricotopus	Midge	Filterer	7	3	4	4	5	7	3	27	1	3	6	11		2	8	15		10	109
				Cricotopus/Orthocladius	Midge	Shredder										2									2
				Cryptochironomus	Midge	Predator	8						4	1											5
				Culicidae	Midge								1												1
				Diamesa	Midge	Collector	5						2		7	1	14				1			11	36
				Diamesinae	Midge	Collector																		1	1
				Diplocladius	Midge	Collector	7	1	2	1							1	2					4	1	12
				Dicrotendipes	Midge	Collector	10	3												1				2	6
				Eukiefferiella	Midge	Collector	8							5			1		1						7
				Helopelopia	Midge	Collector			2		1		4	1				1		2	1		1		13
				Hydrobaenus	Midge	Scraper	8						5			5								1	11
				Limnophyes	Midge	Collector				1							1		1			2			5
				Meropelopia	Midge		7	8	4	15	1	15	3	7	14	1	3	11	8	15	23	31		5	164
				Microtendipes	Midge	Filterer	6				1										3		1		5
				Nanocladius	Midge	Collector	3								1		2								3
				Natarsia	Midge	Predator	8													2					2
				Orthocladiini	Midge	Collector									1										1
				Orthocladius	Midge	Collector	6					4			1	1	1	1				3	7	4	22
				Parametriocnemus	Midge	Collector	5	2	11		3	2	3		1			2				1	2	3	30
				Paraphaenocladius	Midge	Collector	4										1								1
				Paratanytarsus	Midge	Collector	6	1	1		2					1				1					6
				Paratendipes	Midge	Collector	8		1		2														3
				Phaenopsectra	Midge	Collector	7	6		5	5						7	1	2		15				41
				Polypedilum	Midge	Shredder	6	2	1	2	1		1		1		1	1		2	6	1	20	3	42
				Rheocricotopus	Midge	Collector	6		1		1		1		1	1		1					1	9	16
				Rheotanytarsus	Midge	Filterer	6		1														1	2	4
				Smittia	Midge	Collector														1					1
				Stenochironomus	Midge	Shredder	5	1																	1
				Stictochironomus	Midge	Collector	9														2				2
				Sublettea	Midge	Collector			1																1
				Sympotthastia	Midge	Collector	2									2								1	3
				Tanypodinae	Midge	Predator		1						1											2
				Tanytarsus	Midge	Predator	6	3			6		11				2	4			2	1	21	2	52
				Thienemanniella	Midge	Collector			3		4		14			42	2				2			23	90

Table C-1. (Continued)

Phylum	Class	Order	Family	Name	ommon Nar	eeding Grou	lerance Val	MB-1	MB-2	MB-3	MB-5	MB-10	GST-1	GST-2	GST-4	GST-5	GST-8	CS-1	CS-2	CS-3	CS-5	CS-6	CS-7	CS-8	Total
				Thienemann	Midge	Predator	6	6	5				8	6			4	1			2	2			34
				Tribelos	Midge	Collector	5	1																	1
				Tvetenia	Midge	Collector	5		1	1	1	3	1			16	1	2				1	2	3	32
				Zavrelimyia	Midge	Predator	8	2		5		2		10	2	1	2	3	4	3	7				41
			Empididae	Chelifera	Dance Fly	Predator																1			1
				Hemerodror	Dance Fly	Predator	6	1	1									1							3
			Simuliidae	Simulium	Black Fly	Filterer	7		2				1										18	1	22
				Stegopterna	Black Fly	Filterer	7																1		1
			Tipulidae	Antocha	Crane Fly	Collector	5		2		2	3				1								3	11
				Hexatoma	Crane Fly	Collector	4																1		1
				Tipula	Crane Fly	Collector	4					2			1	1								1	5
		Ephemerop tera	Ameletidae	Ameletus	Mayfly	Collector	0																2		2
			Ephemerell idae	Eurylophella	Mayfly	Scraper	4																	2	2
			Heptagenii dae	Stenonema	Mayfly	Scraper	4																2		2
		Odonata	Calopterygi dae	Calopteryx	Damselfly	Predator	6	2		3		1					1								7
			Coenagrion idae	Argia	Damselfly	Predator	8							5			2	1					1		9
				Ischnura	Damselfly	Predator	9	1						4											5
				Coenagrioni	Damselfly	Predator				1						1	1								3
			Gomphidae	Gomphidae	Dragonfly	Predator										1									1
		Plecoptera	Nemourida e	Amphinemu	Stonefly	Shredder	3		1														5		6
		Trichoptera	Hydropsyc hidae	Cheumatops	Caddisfly	Filterer	5	9	12	3	4	3	3	2	11	2		13			5	6	10	6	89
				Diplectrona	Caddisfly	Filterer	2																1		1
				Hydropsych	Caddisfly	Filterer	6	4	3	3		1	2	2	5	6		11				6		4	47
				Hydropsych	Caddisfly	Filterer									2										2
			Philopotam idae	Chimarra	Caddisfly	Filterer	4	5				1													6
				Philopotami	Caddisfly	Filterer									1										1
	Malacostra ca	Amphipoda	Crangonyct idae	Crangonyx	Amphipod	Collector	4	3	4		49	7						9							72
		Isopoda	Asellidae	Caecidotea	Isopod	Collector	8				1														1
Mollusca	Gastropoda	Basommato	Physidae	Physella	Snail	Scraper	8	1		2				8			1			2	1				15
		Limnophila	Ancylidae	Ferrissia	Snail	Scraper	7									1	1			1					3
			Planorbidae	Menetus	Snail	Scraper	8	2																	2
	Pelecypoda	Veneroida	Corbiculida e	Corbicula	Bivalve	Filterer							1												1
			Sphaeriidae	Pisidium	Bivalve	Filterer	8							1						2				1	4
				Sphaeriidae	Bivalve	Filterer											1								1
Nemertea	Enopla	Hoploneme rtea	Tetrastemm atidae	Prostoma	Ribbon Wor	Predator						1					1	1							3
Platyhelmin	Turbellaria	Tricladida	Planariidae	Dugesia	Flatworm		7		8	1	1	3	19					1							33

APPENDIX D

STREAM RESTORATION DATA SHEET

City of Gaithersburg
Restoration Site ID

Reach ID:________________________
Reach Length (m):_________________
Description of Problem:______________
____
____
Possible citizen monitoring site?_______
Latitude: N_______________________
Longitude: W_____________________

Team:______________________________
Date:______________________________
Type of Problem:____________________
Instream = IS
Bank Stability = BS
Riparian = RP
Other = O
Other Type:___________

	Disagree		Agree	Type
Hydrologic Modifications				
Impairment from blockages	1	2	3	☐
Impairment from stormdrain or other pipes	1	2	3	
Impairment from channel alterations	1	2	3	☐
Channel Condition				
Excessive sediment deposition	1	2	3	
Excessive bar formation	1	2	3	
Unstable substrate	1	2	3	
Accelerated lateral channel migration	1	2	3	
Channel downcutting	1	2	3	
Widespread bank instability/erosion	1	2	3	☐
Channel type (planform)	straight	meandering	braided	
Channel slope	low	moderate	high	
Side slopes	low	moderate	high	
Instream habitat				
Heavily silted substrate	1	2	3	
Lack of instream fish cover	1	2	3	
Lack of epifaunal substrate	1	2	3	
Lack of woody debris	1	2	3	
Lack of bank vegetative protection	1	2	3	
Poor stream shading	1	2	3	
Riparian habitat				
Narrow buffer width	1	2	3	☐
Breaks in buffer	1	2	3	
Vegetation showing signs of stress	1	2	3	
Existing wetlands adjacent to area	1	2	3	
Water quality				
Excessive algae	1	2	3	
Organic scum	1	2	3	
High turbidity	1	2	3	
Obvious spills, discharges, plumes, odors	1	2	3	
Trash problems	1	2	3	

Reach ID:________________________ Date:_______________

Property Constraints				
Infrastructure threatened	1	2	3	
Infrastructure damaged	1	2	3	
Site on City-owned land	1	2	3	
Minimal utility relocation required	1	2	3	
Adjacent properties severely impacted	1	2	3	
Suitable access for construction	1	2	3	
Suitable access for maintenance	1	2	3	
Sufficient adjacent land for restoration	1	2	3	
Community acceptability				
Site is not close to houses and roads	1	2	3	
Site has no other safety considerations	1	2	3	
Opportunity for environmental education	1	2	3	
Opportunity for habitat enhancement	1	2	3	
TOTAL SCORE:				

Restoration opportunity	**Poor**	**Fair**	**Good**	**N/A**	**Type**
Bank stabilization	1	2	3	x	
Grade protection	1	2	3	x	
Channel realignment	1	2	3	x	
Profile adjustment	1	2	3	x	
Instream habitat	1	2	3	x	
Low flow channel	1	2	3	x	
Riparian buffer	1	2	3	x	
Wetland protection/creation	1	2	3	x	
SWM facility - new	1	2	3	x	
SWM facility - retrofit	1	2	3	x	
Fish passage	1	2	3	x	

Site sketch:

Description of photos:____

Codes

Impairment From Blockage
D=Dam
RC = Road Crossing
PC = Pipe Crossing
BD = Beaver Dam
NF = Natural Falls/Rapids
KP = Knickpoint
O = Other

Impairment From Channel Alterations
D = Dredged
H = Hardened
S = Straightened
F = Flashy Flows

Widespread Bank Instability/Erosion
LB = Left Bank
RB = Right Bank
BB = Both Banks

Riparian Land Cover
FR = Forest
OF = Old Field
EM = Emergent Vegetation
LN = Mowed Lawn
TG = Tall Grass
LO = Logged Area
SL = Bare Soil
RR = Railroad
PV = Paved Road
PK = Parking Lot/Industrial/Commercial
GR = Gravel Road
DI = Dirt Road
PA = Pasture
OR = Orchard
CP = Cropland
HO = Housing

Utility Type
SW = Sewer/Water
ETP = Electric/TV/Phone

Bank Stabilization
BE = Bioengineering
TE = Traditional Engineering